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PRE-CAMBRIAN IN OHIO.*

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INTRODUCTION.

This probably is the largest topic on our program, about as large a topic as one could select in Ohio. And yet, the subject contains about as little that is really known as any subject one could choose. The material presented here is a by-product of my work on the Physiography of Ohio, where a knowledge of the ancient physiographies of the state is not only interesting, but essential. In consultation with our State Geologist he gave permission to present it and even urged its publication before the bulletin shall be printed. Such a procedure has a double advantage. It brings whatever there is of value before us all some time before it can now possibly come out in the bulletin, and it gives us an opportunity to discuss the problems before publication in a more permanent form. The material to be examined divides easily into three parts which become the section headings used.

PRE-CAMBRIAN SURFACE.

Essentially everywhere in Ohio where older sedimentary rocks are exposed, along the Cincinnati arch and particularly in southwestern Ohio, the rocks are in layers with very low angle dips often so nearly horizontal that without leveling instruments no dip can be detected for miles. Scores of wells in the southwestern quarter of Ohio reach the level of the Trenton beds, the lowest strata exposed in Ohio, and always they are reported present and thus shown to be essentially continuous and at similar depths. It is upon the Trenton

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that the Cincinnati anticline structure is best mapped. In the northwest quarter of the state hundreds of wells have been drilled to the Trenton and the continuity and general depth are found. This can mean at least one thing concerning the pre-Trenton surface, that it was not very rough but rather notably smooth and level when the Trenton materials began to accumulate. Some few wells in western Ohio go through the Trenton and the same simple structure and levelness of beds is also found below. The only departure is the broad, low arch of the Cincinnati anticline which is known to owe its origin to post-Trenton movements.

But in addition to these many wells which end in Trenton and in rare cases in Cambrian with a goodly number stopping in strata of lower Ordovician, we now have several wells that go through all sedimentary material into underlying metamorphics. Data pertinent to our study have been collected and will be stated here.*

The first well to go through was at Findlay and was drilled in 1912.† It penetrated 210 feet into granitic gneiss after going through 2770 feet of sediments. The head of the well has an elevation of 830 feet. Hence the Pre-Cambrian surface at Findlay is 1940 feet below sea level. Two wells a few miles apart in different townships were drilled, but they gave essentially parallel records which are here treated as one well. Another well going through is at Woodville, about 30 miles northeast of Findlay. This one reached granitic gneiss at 2672 feet and penetrated 150 feet. The head of this well is 655 feet above sea level so the Pre-Cambrian surface at Woodville is 2017 feet below sea level. A third well located near Tiffin reached the granitic gneiss at 2950 feet. Since the well-head is at 760 feet above sea level, the Pre-Cambrian surface there is 2190 feet below sea level. The Tiffin well is 28 miles almost directly east of Findlay and 25 miles S. by S. E. from Woodville. These three occupy the corners of a triangle 25, 28 and 30 miles on a side.

Findlay and Woodville are almost on the Cincinnati anticline axis, and at these two places the Pre-Cambrian is nearly at the same altitude, 1940 and 2017 feet below sea level, a

*Dr. Wilber Stout, State Geologist of Ohio; Dr. J. E. Carman, of Ohio State University, and Mrs. Theron Wasson, formerly with the Pure Oil Company, have assisted in bringing these data together. Specific reference to published data can be given for two or three wells.

†American Journal of Science, Vol. 35 (1913), pp. 124–130.

descent of 77 feet in 30 miles. The top of the Trenton descends 187 feet in the same distance. The Tiffin well is down the east slope of the anticline and the Pre-Cambrian surface is at 2190 feet below sea level which gives a descent down the anticline of 250 feet in 28 miles.

At New London, 43 miles east of Tiffin, hence farther down the east flank of the anticline, another well was drilled in 1925. This well reached the Trenton at 3645 feet and penetrated 756 feet of Trenton, but drillers believed they did not go quite through this formation. The well-head is at 991 feet above sea level, hence the top of Trenton is 2654 feet below sea level. Here we have a dip of the Trenton eastward from Findlay to New London of 2319 feet in 71 miles, or 32+ feet per mile. The Pre-Cambrian slope from Findlay to Tiffin is nearly 9 feet per mile, no doubt becoming steeper toward Tiffin. Other wells reaching the Trenton in this part of the state indicate its planeness and its even dip from the vicinity of Tiffin eastward. It may be fair to assume that the Pre-Cambrian follows the Trenton slope down eastward as closely as it follows in the three wells on the triangle. Certainly there is no evidence against this assumption. Such assumption would place the Pre-Cambrian surface at New London at 4259 feet below sea level.

These four wells have found no unevennesses in the Pre-Cambrian surface except those exactly correlated with the Cincinnati anticline. All wells that have stopped in the sediments from the Trenton down have failed to encounter any Pre-Cambrian elevations or thinning of the sedimentary strata as if lying over a Pre-Cambrian hill. This again suggests notable evenness of the Pre-Cambrian surface over this Findlay-Woodville-New London portion of the state.

At South Charleston, 84 miles almost directly south of Findlay and some miles down the east flank of the Cincinnati structure, is the Friend well drilled in 1926-7. The well-head is 1100 feet above sea level. The Trenton was reached at a depth of 1245 feet or 145 feet below sea level. Its thickness was 610 feet, about 120 feet less than in the Findlay region and about as much thinner as found at Waverly in a well to be discussed shortly. The Trenton is 190 feet higher here than at Findlay, an ascent of 2¼ feet per mile, but it rises southward along the axis of the anticline faster than on this N-S line. Below the Trenton was found 800 feet of Ordovician,

665 feet of upper Cambrian and 99 feet of red clastic material, probably middle Cambrian. Thus these sediments continue downward 2319 feet below sea level. The drill next passed through 421 feet of material classed by those who studied it as Upper Keweenawan, and then through 807 feet of black carbonaceous limestones. If these 1228 feet are Pre-Cambrian, the surface we are describing is here about the same depth as at Tiffin—remarkably near the same. Even if all these 1228 feet are Cambrian, which seems a much more probable interpretation to one who has not seen them, and the Pre-Cambrian surface is not far below them, then our Pre-Cambrian surface is some 3547 feet, or a little more, below sea level. Such an interpretation is wholly consistent with the Paleogeographic maps which show the Cambrian seas spreading over Ohio from the south as early as Middle or possibly late Early Cambrian time.

On this more generous interpretation the Pre-Cambrian surface would be placed some 3600 feet below sea level at South Charleston, not as deep on this eastern flank by 600 feet as it surely is at New London. Nor is South Charleston as far down the flank. But with all this increase in depth from Findlay to South Charleston, 1600 feet in 84 miles, we here have only feeble relief, less than 20 feet per mile and much of this is to be accounted for by the position of the South Charleston well with reference to the Cincinnati arch.

For years the Waverly well* drilled about 1910 was interpreted as having reached crystalline rocks called serpentines but in recent years there has been much doubt about this interpretation. In this well near Waverly the Trenton was 729 feet thick and was struck at a depth of 2100 feet. Since the altitude of the well-head is 600 feet, the Trenton was found at 1500 feet below sea level. From South Charleston to Waverly is 60 miles nearly directly down the east flank of the anticline. With the Trenton below sea level 145 feet at the former town and 1500 feet at the latter, the rock dips 22–3 feet per mile. With the Upper Keweenawan (Pre-Cambrian) at 2319 feet below sea level at South Charleston, and the structure descending 22 feet per mile as it does on the Trenton, the Pre-Cambrian could hardly be less than 3674 feet below sea level at Waverly. These so-called serpentine fragments were found at 2720 feet below sea level.

*American Journal of Science, Vol. 31 (1911), pp. 19 ff.

Again, if the so-called Upper Keweenawan and black carbonaceous limestones of South Charleston are also present at Waverly, as seems reasonable on the grounds of an invading Cambrian sea from the south, one could not expect to find Pre-Cambrian higher than 4183 feet below sea level. Thus it seems very probable that whatever the material is that has been called "serpentine fragments" it cannot be Pre-Cambrian. The Pre-Cambrian at Waverly probably will be found over 4000 feet below sea level.

By similar reasoning from the depth to Trenton in southern Ohio, the Pre-Cambrian would have been reached in the Ironton well at not less than 5250 feet below sea level, for the Trenton was found there at 2670 feet below tide.

Summarizing the above paragraphs, we have Pre-Cambrian known at Woodville at 2017 feet below sea level, at Findlay at 1940 feet, and at Tiffin at 2190 feet. Calculating its depth below the Trenton as great as it was found in the three wells New London may have Pre-Cambrian at 4259 feet below sea level. South Charleston has Pre-Cambrian at 2319 if the materials are truly diagnosed as Keweenawan, but a better interpretation seems to place the Pre-Cambrian a little lower than 3547 feet below sea level. These depths find no inequalities in the surface of the old rocks except such as are due to the up-warping of the broad geanticline. Hundreds of wells scattered over western Ohio reaching Trenton or deeper likewise find no other inequalities. Therefore it seems safe to assume that this Pre-Cambrian surface is very remarkably even and smooth with slopes of not more than 2–10 feet per mile except those down the flanks of the anticline. Such a surface across crystalline rocks can be none other than an erosion surface. To have been an erosion surface it must have been much higher than it is now and somewhat, though but little, above sea level. But to consist of such rocks as are found in it, there must once have been hundreds of feet of rock above this Pre-Cambrian surface. Hence, there must have been great Pre-Cambrian erosion to peneplanation in Ohio. Such an erosion surface has been widely recognized elsewhere and the time required to make it has been called the Lipalian interval.

Some support for this interpretation of the character of the Pre-Cambrian surface is found in a well which reaches granite at about 3000 feet below sea level at Amboy, Illinois.

Much more support comes from the gradual disappearance of a similar Pre-Canbrian surface exposed in Canada, Wisconsin, and Minnesota, but sloping down under late Cambrian sediments in Canada and in more southerly parts of these two states. With such gentle decline below younger rocks this surface would reach the depths where we find it in Ohio.

PRE-CAMBRIAN MATERIALS.

This section has much less to offer than the former. Only three wells in Ohio have positively reached the Pre-Cambrian. Each seems to have found red granitic gneiss. If the South Charleston well has reached it, the material is partly clastic, partly limestone, and the latter is not metamorphosed. Diabase dike in sediments and underlain by over 100 feet of Keweenawan is reported in the Greentown well in central northern Indiana at about 3000 feet below sea level.

Perhaps the best evidence we have of the nature of our Ohio Pre-Cambrian materials is in the nature of the known Pre-Cambrian in the north which has been shown to descend as a peneplain beneath the Cambrian and other sediments of these north central states. Everywhere in these northern exposed areas the rocks are crystalline, metamorphosed sediments and tuffs with intrusions and extrusions of granitic and basic material. Our Ohio foundation is known to be Pre-Cambrian, because the Cambrian as unmetamorphosed sediments overlies it everywhere. Hence, in Ohio the rocks which carry this old Pre-Cambrian surface are probably everywhere similar complex crystallines.

Another item suggesting the nature of the materials may be had from the Pre-Cambrian in Canada. Here it is the carrier of several valuable mineral and ore deposits and a large variety of economic materials. The great iron deposits of the Lake Superior region, the copper of the Keweenaw Michigan section, the Sudbury nickel, silver and gold, the cobalt ore, small deposits of gold in a number of places separate from the other metallic ores, asbestos, serpentine marble and a wide variety of good building stones represent both metallic and nonmetallic value in the exposed Pre-Cambrian. Our three or four wells that actually reach Pre-Cambrian in Ohio reach nothing of metallic deposits, but they do reach rock that would be good building stone. The 2000–3000 feet of cover however is sufficient barrier to its economic development.

PRE-CAMBRIAN STRUCTURES.

The third part of this paper concerns itself with structures of Ohio Pre-Cambrian. A suggestion from the exposed rocks of similar age in our Canadian area is our best lead at present. If, as shown and generally believed, the Pre-Cambrian of the north continues underneath the Paleozoic of Ohio it is reasonable to believe that it carries similarly complex structures. But it is just as true that, from this method of reasoning, we can get no clew as to just what structure is where. The pattern is far too intricate, too confused one pattern with another, to infer safely that because a certain structure occurs near the border of the Paleozoic cover its continues 100 miles beneath that cover.

We really have very little suggestion from our wells concerning structure in these old rocks. Three wells in the Findlay-Tiffin-Woodville triangle found very similar granitic gneiss. One might well infer a mass of granitic gneiss in that locality 30–40 miles across, but one cannot well go farther. The well at Greentown, Howard County, Indiana, some miles north of the capital, is reported passing through a diabase "dike" 20 feet thick in the Keweenawan; but we do not know whether it was pierced at right angles so as to give the exact thickness, or very obliquely so as to make a 20-foot section in a dike only a few feet thick. Diabase dikes may occur in other places.

There are now in use several Geophysical methods of studying covered materials and structures. They are not so well perfected that they tell indisputably what occurs below, but they are well worth considering in the exploration of Ohio Pre-Cambrian. Within the last few years the new Hungarian government through the late director of its Geologic Survey, Dr. Hugo de Boeckh, has made a survey of the covered rocks below the plain and has found what the director considers good evidence of several structures in the ancient rocks below the great unconformity. In a conversation regarding the Ohio situation, he said he felt a survey of western Ohio through 2000–3000 feet of sediments, so well-known as ours now are, would be possible and worth while.

Iron deposits might be located by magnetic methods; certainly no mining should be started unless magnetic methods suggest it. Drilling is always in order. Copper bodies,

metallic and sulphide ores, cobalt and nickel ores may be detected by certain electrical methods in which the potential field is measured. Here again no mining should be started until the geophysical testing suggests it. Our methods are not sufficiently perfected to assure one of actually finding ore bodies even when the measurement of the magnetic and electric properties suggests their presence, because other conditions besides proximity of ore bodies produce differences in potential fields. But study of methods and exploratory surveys are now in order and should be carried on as time and means make possible.

Such ore bodies as the Sudbury and Cobalt in Canada are workable in shafts 2000–3000 feet deep. As the iron ores of the Lake Superior region decline, such bodies as they are at the surface might be worked through a cover of 2000–3000 feet. Probably we could not afford to work an Ohio iron-ore body at such depths *now*, even if we should find one; but no doubt the time will come when we shall be glad to work through the Paleozoic cover for iron, copper, nickel, silver and gold. All of these metals are well known in Pre-Cambrian where it is exposed north of our Paleozoic cover, and may be found in the future under our own Ohio soils.

Respiration in Plants.

This is the title of the latest volume to appear in the Dial Press series of monographs on biological subjects. Messrs. Stiles and Leach attempt to encompass within the covers of this little book a modern, consistent, and condensed treatment of the process of plant respiration. The subject matter is discussed under four chapter headings, to-wit: I. Introductory, II. Respiration of normal plants under aerobic conditions, III. Anaerobic respiration, and IV. The mechanism of respiration. The book is well-rounded, concise, and readable. Perhaps inevitably the authors' evaluation of the subject follows somewhat the temper of their own scientific outlook. Nevertheless, this volume is the only modern treatment of the topic of plant respiration with the exception of Kostychev's well known monograph, which it far excels for the many who prefer to do their reading where the essence of the subject has been distilled out of a mass of otherwise very confusing data. There is a list of the literature cited in the text; this is a short but good working bibliography of the subject. A subject-author index completes the volume. The book deserves a careful reading by every advanced student of botany or biology.—B. S. MEYER.

Respiration in Plants, by W. Stiles and W. Leach. 124 pp. New York, The Dial Press, 1932.

ANCIENT DRAINAGE BETWEEN THE OLD CUYAHOGA AND THE OLD PITTSBURGH RIVERS.*

ROBERT SCRANTON AND G. F. LAMB.

The area involved lies between Willoughby, on Lake Erie, on the north, and the headwaters of the Mahoning, on the south. So far as has been known up to the present, the history of the Mahoning river was uneventful. That the old Pittsburgh River flowed by Beaver Falls, Newcastle, Sharon, Youngstown, Warren, and on northward, has long been recognized, and it was thought that the Mahoning joined it at or near Leavittsburgh. It was known that the present Mahoning flows on glacial till from its headwaters to a point about three miles north of Alliance; that from there to Lake Milton it is generally on rock, although crossing several times zones of till, with considerable depths of fill known near the course; and that between Lake Milton and Newton Falls it is on till, at Newton Falls on rock, and thence to Leavittsburgh on till. It was therefore assumed that the preglacial and interglacial courses had been maintained with variations until the present time.

It was on this assumption that the work of definitely plotting the course was begun in the fall of 1931, under the direction of Professor G. F. Lamb of Mount Union College, by Glenn Goss, Austin Schadle, and Robert Scranton. Exploration of the river course itself from its headwaters for about twelve miles downstream confirmed what had been thought before concerning this section. Well records at Alliance showed a depth of as great as two hundred feet, placing the rock floor at about eight hundred forty feet above tide. Another well in the valley of the tributary Beech Creek showed till to a depth of three hundred feet. This part of the river flows consistently on till, with rock at or near the surface on each side of the valley. The first surprise came where the river turns eastward, crossing the Lexington Road about three miles north of Alliance. At this place, at a bridge

*Read before the Ohio Academy of Science, April 29, 1932, under the title "Drainage Changes of the Upper Mahoning River."

about a quarter of a mile south of the county line (see A. on Map I), drillings revealed that on the west side of the road rock was struck at one hundred forty feet, but on the east side, thirty feet distant, rock lay at ninety feet. This developed into a focal point.

For from that time on, no depth could be found in all the region north or east of this point, east of Atwater and south of Palmyra, which comes at all close to the level necessary to handle any drainage whose level is eight hundred forty at Alliance. The river's course, it is true, is on fill in spots, but the fill is shallow, apparently representing mere irregularities of surface on a rolling rock topography.

Very careful combing of the region revealed what at first seemed to be two leads. One is a till filled valley extending south from Newton Falls, to just east of Palmyra, but no trace of it could be located south of the latter village. On the contrary, the rock is well up. The second is a deep, filled valley leading south on Silver Creek from a point just west of Wayland. It seemed to lead south toward the Atwater region by passing east and south of Edinburgh, but ended southeast of there.

On the other hand, a few wells showing good depth were picked up northwest of the Lexington Road bridge, north of Limaville, at Atwater, west of Edinburgh and near Rootstown Station, and near Campbellsport, which is situated on the West Branch of the Mahoning, southwest of Ravenna. All these wells indicate a considerable depth, quite capable of handling any level to the south. They all lie on an axis bearing northwest from the bridge toward Ravenna.

Inasmuch as it was known before hand that there is a deep till-filled valley along the course of the West Branch, it was then thought that the course of the preglacial Mahoning might have been from Alliance to Ravenna, thence eastward to Newton Falls, although the anomaly of such a sharp turn in midcourse was recognized. Investigation seemed at first to indicate a slight fall of the rock floor in this valley, from west to east. No rock was found, all wells being in drift, but successively deeper wells eastward seemed to justify the idea. However, at Newton Falls, there loomed up a barrier. No depth could be found south of Newton Falls, or northwest of the town, capable by from eighty to one hundred feet of handling the depths consistently shown heretofore. The most ex-

haustive field work showed that no deep valley does exist connecting the valley of the West Branch with that of the old Pittsburgh. The rock floor to the west lies at seven hundred fifty feet above tide, but the very lowest point near the Falls is at eight hundred thirty feet above tide. The prevailing level was slightly above this, but no deep narrow valley could be present, as abundant well data proved.

Frustrated at this point, investigation turned west. Traces had been found of a valley north of Campbellsport, east of Ravenna, and it was hoped that this might offer a solution, but wrongly. Westward from Campbellsport, however, there is evidence of an old filled valley. A series of wells indicate that the rock level dips from north and south into a filled valley lying just south of Ravenna leading toward Kent. Other shallow wells show only glacial drift. But just east of Kent a deep well reveals the rock floor at seven hundred seventy-eight feet above tide. Although there is not all the data that one could desire west of Ravenna, yet the data available indicates the presence of a deep valley, and the well at Kent shows the rock floor sufficiently low to care for the valley depth northward from Alliance.

North of Kent, going was easy. Remarkable depths were found at Twin Lakes, west of Streetsboro, Geauga Lake, East of Solon, at strategic points around Chagrin Falls, at Gates Mills, Eagle Mills, north to Pleasant Valley, which is on the Chagrin River about five miles south of Willoughby. These depths occur between rock walls which appear at or near the surface on the east and west for practically the whole distance. The rock floor seems to drop consistently from about seven hundred feet above tide at Geauga Lake to five hundred twenty-five feet above tide at Wilson Mills and five hundred seventy-five feet above tide at Pleasant Valley.

At this point, however, another apparent barrier was struck. This is in keeping with the findings of the late Professor Cushing. Absolutely no till was to be found north of Pleasant valley lower than six hundred thirty feet above tide. As a matter of fact, further investigations revealed that the depths at Pleasant Valley, close to five hundred seventy-five feet above tide, could not be positively connected with the depths at Wilson Mills to the south. There seems to be a hole at Pleasant Valley, although this could not be established certainly. In view of the consistent fall of the rock floor

from the south, this was most surprising, and it must be admitted, disappointing.

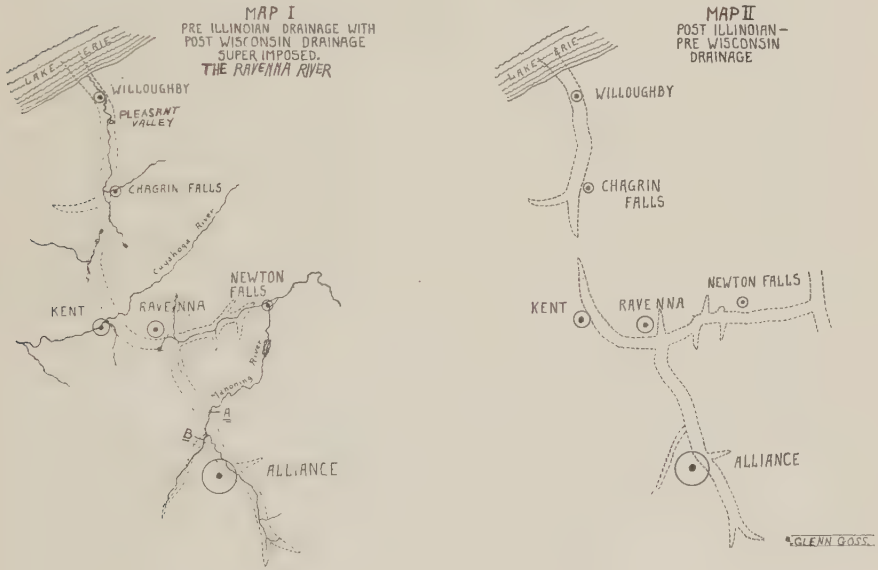
Attempts were made to establish a connection from the Chagrin Valley near Pleasant Valley to a till filled valley found to extend south of Mentor. The latter was the old valley of the East Branch of the Chagrin River, to the east. No joining to the two could be made. It was also attempted to establish a valley northeast from Chagrin Falls along the valley of the East Branch of the Chagrin, but this failed. A lead was followed beginning from a point south of Chagrin Falls, through Solon. A channel was established westward, but its floor ascends toward the west, and it ends just west of Randall. It is thus made clear that the passage was not west by Solon. A stark cul-de-sac in every direction seemed to exist.

An explanation was begun based on the principle of glacial scour. For it is not necessary to assume that the extreme deepening of this and other channels was accomplished entirely by stream action. A clue was found later in a small valley extending east of Pleasant Valley. Here the small stream is flowing on Illinoian drift and on rock. This indicates that the stream, which had eroded a pre-Illinoian valley, had taken its bed down to a level of above seven hundred feet above tide. It was then interrupted by Illinoian glaciation, and in the time since has been able to reduce its bed only to pre-Illinoian Level. Furthermore, field evidence indicates that the deep inner valleys of the various pre-glacial streams of the region were excavated after earliest glaciation, but before the Illinoian.

Thus it would seem that the extreme depths to five hundred seventy-five and five hundred twenty-five feet above tide were not made by stream action, but by glacial scour. This is corroborated by the apparent pocket at Pleasant Valley. Here the valley is about a quarter of a mile wide. The rock is at the surface on the surrounding high ground, approximately one hundred feet or more above the river. Drift is found as far down as one hundred feet below the river, in some places in a nearly vertical drop. The northern end is practically a vertical drop of one hundred feet from river level, and the southern end seems to be blocked off by a rock floor lying higher than the lowest depths. Other corroboration is to be found in the peculiar depth of three hundred feet on

Beech Creek, near Alliance (see B on Map I), in some otherwise inexplicable depths on the West Branch of the Mahoning, and in other scour features of the region.

According to this hypothesis, the drainage lines of the Tertiary toward the north were resumed after early glaciations, up to the Illinoian. Prior to Illinoian, there was a river whose course was from the region of the present headwaters of the Mahoning, passing by Alliance, Ravenna, Kent, Chagrin Falls, and Willoughby, into the Lake Erie Basin. At Ravenna it



received a stream flowing westward in the valley now occupied by the West Branch, and in addition, probably another stream from the southwest. Since the river headed in the same region as the present Mahoning and was cut by several modern lines of drainage, and parts of its course are included by several modern lines, it is obvious that a distinctly individual system is being considered. It may be called the Ravenna River, since Ravenna is at the conjunction of its principal tributaries and at the midpoint of its course. It is shown on Map I.

The Ravenna River was not permanently diverted until Illinoian time, when it was forced before the ice front to a new outlet through the valley of the West Branch, passing south

of Newton Falls, probably, where it broke over a divide and proceeded into the old Pittsburgh River. This second course was maintained through Illinoian time. It is thought that the Illinoian terminal moraine lay to the north of Ravenna, as no Illinoian till has been found as far south as that town, so that on the retreat of the ice sheet the moraine formed a divide that maintained the eastward diversion through the followed interglacial stage as illustrated on Map II.

In that part of the area in question north of the terminal moraine, it is thought that the greatly diminished drainage was barely able to cut through the Illinoian till and therefore the rock floor in the vicinity of Willoughby and southward was lowered little if any before the Wisconsin advance.

The proposed course of the river from early Illinoian to Wisconsin is based on the following points. First, the present course from about three miles north of Alliance to Pricetown is obviously a new channel. Second, there is a definite ancient channel from Alliance to Campbellsport and eastward passing Newton Falls, over a divide. And third, we have no reason for believing that the Illinoian ice sheet ever reached farther south than a few miles north of Ravenna.

The second drainage was disturbed by Wisconsin glaciation. Till carried and dropped by this ice sheet obliterated the valley from Alliance to Ravenna. On the retreat of the ice, the waters found their way out by their present course, from Alliance directly to Newton Falls.

Evolution.

A scholarly presentation of the basic facts supporting the theory of evolution, written in an exceedingly readable style. The subject is discussed largely from the modern genetic view-point. Following an introductory explanation of chromosomes and the chromosome hypothesis of heredity, attention is directed to the influence of selection, natural and artificial. A discussion of mutation is included. Embryonic development, including a critique of the recapitulation theory, forms the basis for an interesting chapter, followed by a thoroughly scientific attack on the inheritance of acquired characters. Evolution in its relation to the human race is discussed, and the book closes with a valuable presentation and comparison of various mechanistic and metaphysical theories of evolution. The volume is highly recommended for the general reader and the serious student of biology.—L. H. S.

The Scientific Basis of Evolution, by T. H. Morgan. 286 pp., incl. bibliography. New York, W. W. Norton and Co., Inc., 1932.

THE GENUS TEMNOGAMETUM.

EDGAR NELSON TRANSEAU,
Ohio State University.

The genus Temnogametum was established by W. and G. S. West in 1897 to include those species of the *Zygnemaceae* with vegetative cells and chromatophores similar to those of *Mougeotia*, but in which the gametangia are clearly differentiated from the vegetative cells prior to conjugation.

Czurda* has called attention to the well known fact that conjugation always occurs between youthful cells, and he therefore concludes that the lengths of conjugating cells (gametangia) are of no significance. Such cells would probably elongate the same as vegetative cells were it not for the organization of gametes and subsequent conjugation. In the one species of Temnogametum that I have seen there is abundant evidence that the gametangia do not elongate when conjugation fails. Furthermore these short cells are not to be identified with the occasional or rare short cells that every experienced collector has seen in field collections and which Czurda figures from his clone cultures.

A second reason advanced by Czurda for not recognizing *Temnogametum* as distinct from *Mougeotia* is his claim that lateral conjugation is the same in both genera. What I have described and figured as "aplanospores" in the paper on "The Genus Mougeotia"† he interprets as zygospores formed by lateral conjugation. This interpretation rests on an observation of a case of lateral conjugation in a clone approaching *M. viridis* in form. I do not question this observation, but I have watched the formation of these spores in several other species, and particularly in *M. prona*, where I had essentially a pure culture in a small spring near Cold Spring Harbor, L. I. No other algae were present except a few species of desmids. For six weeks I made collections at frequent intervals and examined them in the living condition, and had them developing in glass dishes in the laboratory. During that period I examined

*Czurda, Viktor. Zur Morphologie und Systematik der Zygnemalen. Beih. zum Bot. Cent. 48: 2; 238. 1931.

†Ohio Journal of Science, 26: 311–338. 1926.

several thousand spores in all stages of development with this particular point in mind, but I never saw the nucleus divide nor any suggestion of a division of the cytoplasm and formation of a dividing wall.

But even granting that the "aplanospores" figured by Wittrock, Borge, West, and myself are in reality zygotes formed by the union of two partially developed gametes, the whole process is quite different from that which takes place in *Temnogametum*. In *Mougeotia* the contents of a long vegetative cell contracts to the middle of the cell leaving behind a certain amount of cytoplasmic residues. Cross walls are then formed separating this median cell (sporangium) from the two non-living ends of the cell. Czurda thinks this follows a division of the protoplasm and that the median cell is the result of a subsequent union.

In Temnogametum, on the other hand, two adjoining vegetative cells cut off gametangia adjacent to one another with a primary cell wall separating them. The vegetative cells on either side of the pair of gametangia remain alive, and the gametangia accumulate foods and become very dense as compared with the vegetative cells from which they were cut off. Then the primary separation wall is dissolved and the two gametes formed from two distinct vegetative cells unite and form a zygote. Surely this is a very different process from that which occurred in Czurda's clone culture of *M.* (?) *viridis*.

For these reasons I cannot accept Czurda's proposal to merge the species of *Temnogametum* with *Mougeotia*. I agree that they are evidently closely related, but are sufficiently distinct, morphologically and physiologically, to merit separation in different genera.

At present only three species are known: one from Welwitsch's collections in Africa, one from Ule's collections in Southern Brazil, and a third from Thaxter's collections on the Island of Trinidad. Thus far the species are tropical or subtropical in their occurrence.

The genus and species may be defined as follows:

Temnogametum W. & G. S. West, 1897.

Vegetative cells cylindrical, 2 to 25 diameters long; chromatophore an axile plate containing several or many pyrenoids; isogamous gametangia distinct and cut off from the ends of vegetative cells; conjugation scalariform or lateral, resulting in the formation of two

types of zygospores. Aplanospores and parthenospores also formed in some of the non-conjugating short cells. In none of the collections thus far seen has there been a separation of the spore wall and sporangium into distinct layers.

1. *T. heterosporum* W. & G. S. West, 1897. African Freshwater Algae, Jour. Bot. 35: 37. Pl. 370, Figs. 5–9; G. S. West, Algae, pp. 340–341, Fig. 212. 1916; Czurda, Zygnemales; Süsswasserflora Mitteleuropas; 9: 98. 1932.

Diameter vegetative cells 14.5–17μ, length 6–12 diameters, chromatophore with 1–6 (usually 5) small globular pyrenoids arranged in a single row; gametangia 22–40μ in length; zygospores, formed by scalariform conjugation cruciate with convex sides and truncate angles, occupying the gametangia and tube, 39–50μ $\times$ 48–59μ; zygospores formed by lateral conjugation obliquely ovoid with truncate ends occupying the united gametangia 20–26μ $\times$ 61–67μ; spore wall smooth, colorless. Plate I, Figures 9–13.

Morro de Lopollo, Angola, Africa, Feb., 1860. Welwitsch.

2. *T. uleana* (Moebius) Wille, 1909. Pflanzenfamilien, Nachtrage zum 1 Teil, 2 abt., page 13, Fig. 3; Moebius, Ueber einige brazilianische Algen, Hedwigia 34: 175–177, Pl. II, Figs. 1–10. 1895. Czurda, Zygnemales; Süsswasserflora Mitteleuropas: 9: 97. 1932.

Diameter vegetative cells 10–12μ, length 6–10 diameters, at time of conjugating elongating to 20–25 diameters, cell sap purple; chromatophore an axile plate with usually four pyrenoids; gametangia 20–30μ long; zygospores usually formed by lateral conjugation, obliquely ovoid to ovoid, 20–40μ $\times$ 40–60μ; the less frequent zygospores formed by scalariform conjugation cruciate-quadrate with truncate angles 25–40μ $\times$ 30–50μ; spore wall smooth and colorless (spore dimensions estimated from Moebius figures). Aplanospores formed in the short cells rarely. Plate I, Figures 1–8.

Agulhas Negras (alt. 2,500 m.), near Itajahy, Southeastern Brazil, March, 1894. E. Ule.

Temnogametum thaxteri sp. nov.

Diameter vegetative cells 39–45μ $\times$ 220–360μ (—510μ), (5–10 diameters long), cell sap purple, chromatophore with 30 to 120 pyrenoids, gametangia 36–90μ long; zygospores formed only by scalariform conjugation, quadrangular ovoid with truncate or rounded corners 60–75μ (—100μ) $\times$ 90–120μ; occasionally formed in pairs by union of two pairs of gametangia, each zygospore being somewhat narrower and longer; zygospore wall thick, smooth and colorless; aplanospores may develop within the short cells, which become more or less enlarged, ovoid, about 60μ $\times$ 75μ, with wall similar to that of the zygospores. Plate I, Figures 14–20.

Sandy pools in Aripo Savanna, Cumuto Station, Trinidad, B. W. I., April 10, 1913. R. Thaxter.

EXPLANATION OF PLATE.

Figs. 1–5. *Temnogametum uleana.* Stages in the formation of zygospores by lateral conjugation. After Moebius.

Figs. 6–8. *T. uleana.* Zygospores formed by scalariform conjugation. After Moebius.

Figs. 9–13. *T. heterosporum.* Lateral and scalariform conjugation. After West.

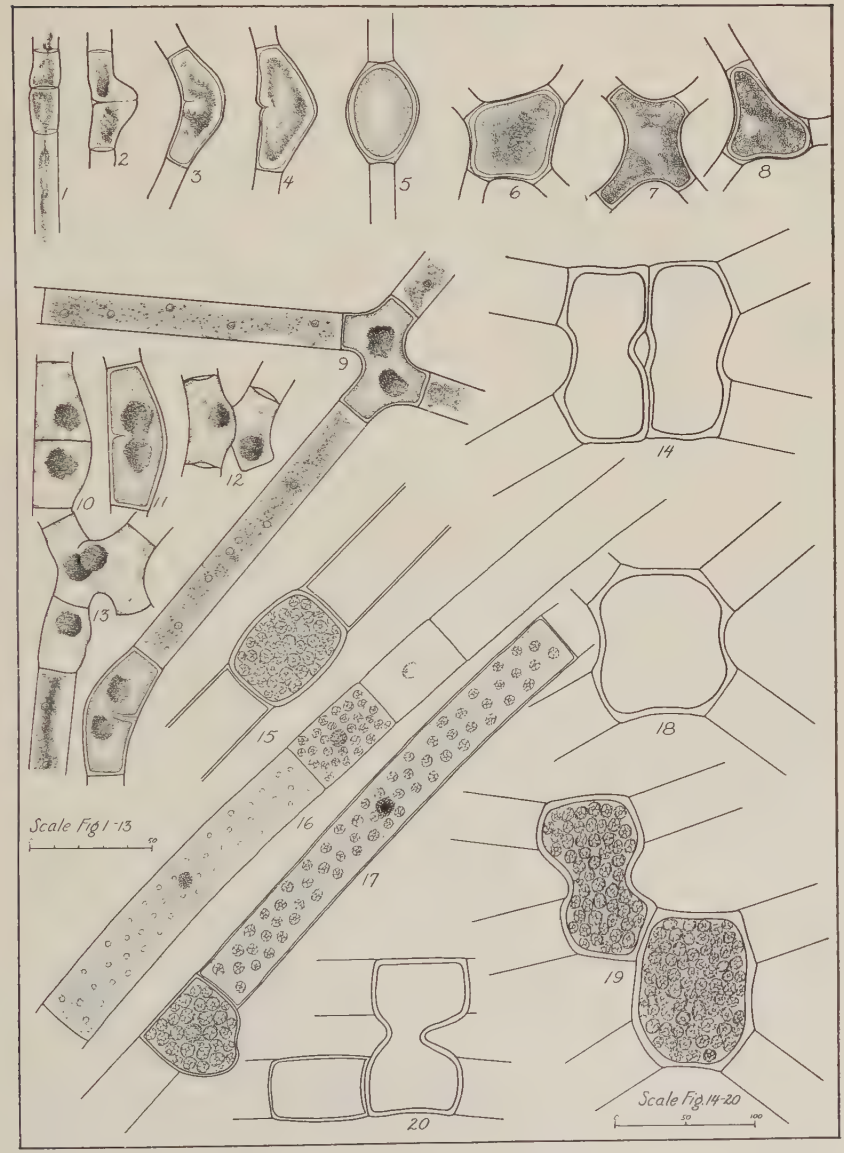
Fig. 14. *T. thaxteri.* Paired zygospores formed by scalariform conjugation of paired gametes.

Fig. 15. *T. thaxteri.* Aplanospore formed from a single gamete.

Fig. 16. *T. thaxteri.* Paired gametangia, each cut off from adjoining vegetative cells. Note increased number of pyrenoids, and their enlargement due to starch accumulation.

Fig. 17. *T. thaxteri.* Vegetative cell and parthenospore.

Figs. 18–20. *T. thaxteri.* Variations in form of zygospores. In Figure 19 the enlarged and crowded pyrenoids are shown. In Figure 20 a pair of gametes in two filaments have united, the unpaired gamete has formed an aplanospore.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Scale Fig 14-20

OKLAHOMA ROTIFERS.

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The repeated appearance of rotifers in the algal collections suggested the importance of a taxonomic study of the group within the state. It was found that upon intensive collecting and a study of existent algal collections, the rotifer fauna was abundant and widely distributed. These facts alone indicated the importance of such a group to the student of aquatic biology, or of still more vital interest to the teacher of aquatic biology, who comes into almost daily contact with its members.

As the literature, at present available for the study of rotifers is not abundant, and which is, moreover, widely scattered, the apparent need was for a summary of the common rotifers, including plates, by which a rapid and accurate identification would be possible.

This paper does not attempt to present a complete list of all the rotifers in the state, but it does offer a means for identification of some of the more common forms. Furthermore it is hoped it will stimulate an interest in the study of the group in other regions as well in the State of Oklahoma.

Most of the rotifers included belong to the loricate or semiloricate groups due to the fact that identifications were made from preserved material, which the circumstances during collection made necessary. The illoricate forms, composing a minor group, such as those from the genera *Philodina*, *Rotifer*, and *Notommata*, are practically impossible to identify when dead, unless especially fixed and preserved. Such a process is rather impracticable in the field. The loricate and semiloricate forms, due to their more or less hardened outer covering, may be identified without the aid of the delicate internal structures, by using only the shape and sculpturing of the lorica. In most cases the eye, or eyes, remain intact after death, thereby furnishing another valuable aid in identification.

Although the most intensive collecting was carried on in the central part of the state, many collections were secured from other regions. These were sufficient in number to warrant the list as being a representative one for the state.

I wish to express my appreciation to Dr. A. O. Weese, of the Zoology Department of the University of Oklahoma, for the advice and helpful criticism which he has given. I also wish to thank the members of the Botany and Zoology Departments of that University for the collections which they have made. To my wife, Celeste Whaley Taft, I extend my sincerest appreciation for assistance in collecting, identification of species, and proof reading.

Following is a list of the Genera identified. The second name, which in a number of cases follows the first, is the new generic name proposed by Harring in 1913.

1. *Philodina* Ehrenberg.
2. *Rotifer* Schrank.
   Rotaria (Scopoli) Harring, 1913.
3. *Melicerta* Schrank.
   Floscularia (Cuvier) Harring, 1913.
4. *Floscularia* Oken.
   Collotheca (Harring), *g. n.*, 1913.
5. *Apsilus* Metschnikoff.
   Cupelopagis (Forbes) Harring, 1913.
6. *Asplanchna* Gosse.
7. *Pedalion* Hudson.
   Pedalia (Barrois) Harring, 1913.
8. *Triarthra* Ehrenberg.
   Filiana (Bory) Harring, 1913.
9. *Polyarthra* Ehrenberg.
10. *Microcodon* Ehrenberg.
11. *Copeus* Gosse.
12. *Notommata* Gosse (nec Ehr.).
13. *Proales* Gosse.
14. *Furcularia* Ehrenberg.
    Encentrum (Ehrenberg) Harring, 1913.
15. *Eosphora* Ehrenberg.
16. *Anuraea* Gosse (nec Ehr.).
    Keratella (Bory de St. Vincent) Harring, 1913.
17. *Notholca* Gosse.
18. *Eretmia* Gosse.
19. *Pterodina* Ehrenberg.
    Tesludinella (Bory) Harring, 1913.
20. *Brachionus* Ehrenberg.
21. *Noteus* Ehrenberg.
    Platyias (Harring), *g. n.*, 1913.
22. *Stephanops* Ehrenberg.
    Squatinella (Bory) Harring, 1913.
23. *Mastigocerca* Ehrenberg.
24. *Rattulus* Ehrenberg.
    Trichocerca (Lamarck) Harring, 1913.
25. *Coelopus* Gosse.

26. *Salpina* Ehrenberg.
Mytilina (Bory) Harring, 1913.
27. *Diaschiza* Gosse.
28. *Dinocharis* Ehrenberg.
Trichotria (Bory) Harring, 1913.
29. *Scaridium* Ehrenberg.
30. *Euchlanis* Ehrenberg.
31. *Cathypna* Gosse.
Lecane (Nitzsch) Harring, 1913.
32. *Distyla* Eckstein.
Lecane (Nitzsch) Harring, 1913.
33. *Monostyla* Ehrenberg.
34. *Colurus* Ehrenberg.
35. *Metopidia* Ehrenberg.
Lepodella (Bory) Harring, 1913.

An Artificial Key for the Determination of the Subclasses, Orders, Suborders, Families, and Genera, of the Class Rotifera.

Keys to the species have been purposely omitted from this paper in order to simplify identification. Keys not accompanied by diagrams are practically useless, and when present along with the diagrams tend to confuse the investigator, who in the end usually resorts to the drawings for the final identification. As only a few species were found in any one genus, and as these are all figured, it was felt that species keys were not essential.

1. Usually microscopic organisms of greatly varied sizes and outlines. In all cases having a ciliated area at the anterior end which varies extensively throughout the group. The body may be either soft (worm-like), or encased in a more or less distinctly stiffened cuticle (lorica). It usually extends posteriorly to some sort of a stalk or foot. The alimentary tract, when complete, has a pharynx with a pair of chitinous jaws and a dorsal cloacal opening near the foot. The excretory system consists of flame cells. In most cases there is a well developed nervous system with a distinct brain. Males of only a few species are known. When found they are smaller than the females, and are almost always degenerate.
Class Rotifera.

2 (7). Females having two ovaries; no lorica.
Subclass Digononta.

3 (8) (14). Body soft (worm-like); creeping worm-like, or swimming by means of the expanded corona; jaws ramate.
Order Bdelloida.

4. Corona composed of two ciliated discs, projecting from the head on short broad stalks.
Family Philodinadae.

5 (6). Eyes two, located in the neck and over the brain.
Genus Philodina, spp. *roseola* (Fig. 1), *aculeata* (Fig. 2).

6 (5). Eyes two, located in the dorsal probosis.
Genus Rotifer, sp. *macrurus* (Fig. 3).

7 (2). Females having one ovary; with or without a definite lorica.
Subclass Monogononta.

8 (3) (14). Forms usually attached by means of a cup or disc at the end of the foot; generally tube builders; in free swimming forms the tube is transparent and is carried about with the organism.
Order Rhizota.

9 (11). Individual or colonial....10

10. Corona not produced into greatly elongated lobes; lobes four, edged by groups of strong cilia which are unequal in length.
Family Melicertadae, Genus Melicerta, sp. *ringens* (Figs. 4 and 5).

11 (9). Never colonial....12

12 (13). Corona usually produced into elongated lobes of varying number, lobes edged by long radiating setae.
Family Floscularadae, Genus Floscularia, spp. *campanulata* (Fig. 6, *sp.* (Fig. 7).

13 (12). Corona never lobed or produced, but composed of a large membraneous sac; foot a flat disc.
Family Apsilidae, Genus Apsilus, sp. *bucinedax* (Fig. 8).

14 (3) (8). Forms not permanently attached; never colonial, and without tubes; jaws never ramate.
Order Ploima.

15 (35). Illoricate forms, not having the body cuticle hardened to form a shell.
Suborder Illoricata.

16 (23). No foot present....17

17 (18). Body large, clear, no appendages; jaws incudate; viviparous; one eye.
Family Asphanchnadae, Genus Asplanchna, sp. *Brightwellii* (Fig. 9).

18 (17). Body varying in size, bearing movable spines, blades, or branching appendages.
Family Pedalionadae.

19 (20). Appendages branched, six in number; two eyes.
Genus Pedalion, sp. *mirum* (Fig. 11).

20 (19). Appendages not branched.
Family Triarthradae.

21 (22). Appendages three, very long, one ventral, and two lateral, ventral shorter than the lateral.
Genus Triarthra, sp. *longiseta* (Fig. 10).

22 (21). Appendages twelve, blade-shaped, with serrate margins, arranged in four groups of three each; one eye.
Genus Polyarthra, sp. *platyptera* (Fig. 12).

23 (16). Foot present.....24

24 (25). Foot ending in one toe; mouth located in the center of a coronal ring of strong cilia; one eye.
Family Microcodontidae, Genus Microcodon, sp. *clavus* (Fig. 13).

25 (24). Foot ending in two toes; no body appendages; corona a densely ciliated oblique area without prominences; some forms with two lateral, ciliated, retractile auricles.
Family Notommatadae.

26 (33). Organisms with one eye.....27

27 (32). Eye not located in the extreme anterior end of the body, but in the neck and attached to the brain.....28

28 (29). Body large, not crenulate; corona usually extending onto a large, movable, ciliated "lip;" body projecting beyond the foot in a sac-like tail; toes large.
Genus Copeus, sp. *labiatus* (Fig. 14).

29 (28). Body small to medium size.....30

30 (31). Auricles present; toes small; body often ending in a large tail.
Genus Notommata, sp. *aurita* (Fig. 15).

31 (30). Auricles never present; corona often an oblique ciliated surface, or even extending to the ventral surface; body small.
Genus Proales, sp. *petromyzon* (Fig. 16).

32 (27). Eye nearly always at the extreme anterior end of the body; body cylindrical, conical in front; two toes, large and conspicuous.
Genus Furcularia, sp. *forficula* (Figs. 17 and 18).

33 (26). Organisms with three eyes.....34

34. One eye larger than the other two, and located posteriorly from them.
Genus Eosphora, sp. *digitata* (Fig. 19).

35 (15). Loicate forms, having the body cuticle hardened to form a shell.
Suborder Loricata.

36 (42). Foot absent.....37

37. Lorica usually six-toothed in front, with or without spines behind, both ends open.
Family Anuraeadae.

38 (41). Lorica oblong, or elongated oblong, dorsal surface convex, ventral surface plane.....39

39 (40). Dorsal surface marked off into polygonal areas.
Genus Anuraea, spp. *aculeata* (Fig. 20), *serrulatus* (Fig. 21), *cochlearis*, var. *macrocantha* (Fig. 23).

40 (39). Dorsal surface without definite areas, but having longitudinal striations.
Genus Notholca, sp. *acuminata* (Fig. 22).

41 (38). Lorica sac-like; the anterior end open, narrower than the closed posterior end, serrate; posterior end with five or six lateral and terminal, long, sharp spines; surface of lorica divided into diamond-shaped areas.
Genus Eretmia, sp. *cubeutes* (Fig. 25).

42 (36). Foot present.....43

43 (46). Foot transversely wrinkled, retractile.....44

44 (45). Foot ending in a ciliated cup; lorica thin, strongly flattened dorso-ventrally; corona a ciliary wreath of two lateral semi-circles; two eyes.
Family Pterodinadae, Genus Pterodina, sp. *patina* (Fig. 24).

45 (44). Foot ending in two small toes; lorica with dorsal, and sometimes ventral anterior spines; posterior spines may be present; lorica strongly convex above, flattened or slightly convex below. (In one species of the following genus, *militaris*, the foot is not transversely wrinkled, but is jointed.)
Family Brachionidae, Genus Brachionus, spp. *pala* (Fig. 27), *sp.* (Fig. 26), *rubens** (Fig. 28), *militaris* (Fig. 30), *angularis* var. *caudatus* (Fig. 29), *Mulleri* (Fig. 31).

46 (43). Foot not transversely wrinkled, not retractile.....47

47 (48). Lorica flattened; both anterior and posterior spines present; no eyes.
Genus Noteus, sp. *quadricornis* (Fig. 32).

48 (47). Lorica cylindrical, covering both dorsal and ventral surfaces; head covered by a broad almost circular, non-movable plate.
Genus Stephanops,† spp. *muticus* (Fig. 33), *sp.* (Fig. 35).

49 (57). Foot very short, with one, two, or more slender toes....50

50 (54). Lorica enclosed entirely around the body, ends open, cylindrical, fusiform, or ovate, usually asymmetrical; one eye.
Family Rattulidae.

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*Rousselet, Journ. Quekett Micros. Club, 1907, claims the specimen of Hudson and Gosse to be wrongly described and identified.

†The genus Stephanops is a very difficult genus to classify. It probably belongs more nearly in the Family Dinocharidae than in the Brachionidae, but because of several varying characteristics it seems to be more easily keyed under the latter. If the user of this key will kindly remember that it is purely an artificial one, it should cause no grave concern.

51(52)(53). Toes single, long and straight, sometimes with other short accessory toes.
Genus Mastigocerca, spp. *capucina* (Fig. 34), *macera* (Fig. 38), *rattus* (Fig. 37), *sp.* (Fig. 36).

52(51)(53). Toes two, equal, bristle-like, having a length of half, or less than half that of the body.
Genus Rattulus, spp. *tigris* (Fig. 39), *cylindricus* (Fig. 40).

53(51)(52). Toes two, unequal, bristle-like, the shorter being more than half the length of the longer; accessory toes may be present.
Genus Coelopus, sp. *tenuoir* (Fig. 41).

54 (50). Lorica not closed on a line down the middle of the dorsal surface, but having the two sides connected by a membrane; toes blade-shaped.
Family Salpinadae.

55 (56). Lorica a well developed box-like structure having the ends open, and with a distinct median dorsal cleft; both anterior and posterior ends with spines; one eye.
Genus Salpina, spp. *spinigera* (Fig. 42), *eustala* (Fig. 43).

56 (55). Lorica not well developed, median dorsal cleft indistinct, no spines; one eye.
Genus Diaschiza, spp. *hoodii* (Fig. 44), *semiaperta* (Fig. 45), *sp.* (Figs. 46 and 47).

57 (49). Foot long, usually of several joints.....58

58 (61). Lorica vase-shaped, entire; head with a chitinous cap.
Family Dinocharidae.

59 (60). Lorica thickened, faceted roughened; no spines; foot with two dorsal spines, foot and toes about as long or slightly longer than the body; one eye.
Genus Dinocharis, spp. *pocillum* (Fig. 48), *tetractis* (Fig. 49).

60 (59). Lorica thin, transparent, smooth; toes, foot, and body about the same length; eye on the mastax.
Genus Scaridium, sp. *longicaudum* (Fig. 50).

61 (58). Lorica not vase-shaped, but ranging from subcircular, circular, subovate, ovate, to elliptical in outline.....62

62 (69). Lorica composed of two plates, located dorsally and ventrally.....63

63 (64). Plates dissimilar, the dorsal one larger and strongly convex; body ending posteriorly in a jointed foot having two rather large blade-shaped toes.
Family Euchlanidae, Genus Euchlanis, spp. *deflexa* (Fig. 51), *uniseta* (Fig. 53), *macrura* (Fig. 52).

64 (63). Plates more nearly alike, separated by a deep lateral furrow having a flexible membrane; the body ending posteriorly in one or two rather large, rod-like toes; the foot is inconspicuous.
Family Cathypnadae.

65 (68). Two toes.....66

66 (67). Lorica ovate, oval, to subcircular; lateral cleft deep.
Genus Cathypna, spp. *luna* (Fig. 54), *leontina* (Fig. 55).

67 (66). Lorica elongate-ovate, slightly extended behind, lateral cleft indistinct.
Genus Distyla, spp. *ohioensis* (Fig. 56), *gissensis* (Fig. 57), *sp.* (Fig. 58).

68 (65). One toe.
Genus Monostyla, spp. *quadridentata* (Fig. 59), *lunaris* (Fig. 60), *Bulla* (Fig. 61), *sp.* (Fig. 62).

69 (62). Lorica composed of a single plate, which may be slightly compressed laterally, or dorso-ventrally flattened; the head is covered by an over-hanging chitinous shield.
Family Coluridae.

70 (71). Lorica slightly compressed laterally, arched dorsally, open at the ends, sometimes open ventrally.
Genus Colurus, spp. *grallator* (Fig. 63), *bicuspidatus* (Fig. 64).

71 (70). Lorica not laterally compressed, the surface with definite sculptured areas, and with a mid-dorsal and a mid-ventral ridge extending backward from the anterior end about to the mid-point of the body.
Genus Metopidia, spp. *Ehrenbergii* (Figs. 65 and 66), *oxysternon* (Figs. 67 and 68), *solidus* (Fig. 69).

A list of the species figured in this paper follows, along with their habitat and general distribution in the state. As previously stated, many of them bear two names, due to the fact that Harring in 1913 changed the generic names of a number of forms, and gave in defense of this change the rule of priority of nomenclature. Because most of the literature available describes the species under the old name it was thought best to include both names in the present paper.

1. *Philodina roseola* Ehrenberg.....Fig. 1
Cosmopolitan in locality and habitat.
Length, .31 mm.

2. *Philodina aculeata* Ehrenberg.....Fig. 2
Cosmopolitan in locality and habitat.
Length, .66 mm.

3. *Rotifer macrurus* Schrank.....Fig. 3
Rotaria macrurus (Schrank) Harring, 1913.
Shawnee Lake; quiet, weedy ponds.
Length, .3 mm.

4. *Melicerta ringens* Schrank.....Figs. 4, 5
Floscularia ringens (Schrank) Harring, 1913.
Shawnee Lake; quiet, weedy ponds.
Length, .64 mm.

5. *Floscularia companulata* Dobie.....Fig. 6
Collotheca companulata (Dobie) Harring, *g. n.* 1913.
Horseshoe Lake; stagnating pond.
Length, .2 mm.

6. *Floscularia sp.*.....Fig. 7
Collotheca sp. Harring, *g. n.* 1913.
Canadian River Oxbow; quiet, muddy water.
Length, .49 mm.

7. *Apsilus bucinedax* Forbes.....Fig. 8
Cupelopagis bucinedax (Forbes) Harring, 1913.
Indian Springs; clear, running water.
Length, 1.77 mm.

8. *Asplanchna brightwellii* Gosse.....Fig. 9
Lake Overholser; plankton.
Length, 1 mm.

9. *Triarthra longiseta* Ehrenberg.....Fig. 10
Filinia longiseta (Ehrenberg) Harring, 1913.
Lake Overholser; plankton.
Length, .9 mm.

10. *Pedalion mirum* Hudson.....Fig. 11
Pedalia mirum (Hudson) Harring, 1913.
Lake Overholser; plankton.
Length, .21 mm.

11. *Polyarthra platyptera* Ehrenberg.....Fig. 12
Lake Overholser; plankton.
Length, .15 mm.

12. *Microcodon clavus* Ehrenberg.....Fig. 13
Shawnee Lake; quiet, weedy ponds.
Length, .25 mm.

13. *Copeus labiatus* Gosse.....Fig. 14
Indian Springs; clear, quiet water.
Length, .9 mm.

14. *Notommata aurita* Ehrenberg.....Fig. 15
Indian Springs; clear, quiet water.
Length, .27 mm.

15. *Proales petromyzon* Ehrenberg.....Fig. 16
Indian Springs; clear, running water.
Length, .15 mm.

16. *Furcularia forficula* Ehrenberg.....Figs. 17, 18
Encentrum forficula (Ehrenberg) Harring, 1913.
Indian Springs; clear, quiet water.
Length, .15 mm.

17. *Eosphora digitata* Ehrenberg.....Fig. 19
Horseshoe Lake; weedy, semi-stagnant water.
Length, .75 mm.

18. *Anuraea aculeata* Ehrenberg.....Fig. 20
Keratella aculeata (Ehrenberg) Harring, 1913.
Lake Overholser; plankton.
Length, .18 mm.

19. *Anuraea serrulatus* Ehrenberg.....Fig. 21
Keratella serrulatus (Ehrenberg) Harring, 1913.
Meeker; grass grown cattle tank.
Length, .11 mm.

20. *Anuraea cochlearis* Gosse var. *macrocantha* Gosse.....Fig. 23
Keratella cochlearis (Gosse) var. *macrocantha* (Gosse) Harring, 1913.
Horseshoe Lake; quiet, weedy water.
Length, .13 mm.

21. *Notholca acuminata* Ehrenberg.....Fig. 22
Edmond; clear, running water.
Length, .27 mm.

22. *Pterodina patina* Ehrenberg.....Fig. 24
Tesludinella patina (Ehrenberg) Harring, 1913.
Arbuckle Mts., Canadian River Ox-bow, Shawnee Lake; cosmopolitan.
Length, .17 mm.

23. *Eretmia cubeutes* Gosse.....Fig. 25
Indian Springs; clear, quiet water.
Length, .06 mm.

24. *Brachionus* sp.....Fig. 26
Lake Overholser; plankton.
Length, .3 mm.

25. *Brachionus pala* Ehrenberg.....Fig. 27
Horseshoe Lake; plankton.
Length, .32 mm.

26. *Brachionus rubens* Ehrenberg.....Fig. 28
Canadian River Ox-bow; muddy, standing water.
Length, .24 mm.

27. *Brachionus angularis* Gosse var. *caudatus* Dad.....Fig. 29
Lake Overholser; plankton.
Length, .25 mm.

28. *Brachionus militaris* Ehrenberg.....Fig. 30
Ten Mile Flats; weedy, stagnant pond.
Length, .18 mm.

29. *Brachionus Mulleri* Ehrenberg.....Fig. 31
Great Salt Plains; very brackish water.
Length, .24 mm.

30. *Noteus quadracornis* Ehrenberg.....Fig. 32
Platyias quadracornis (Ehrenberg) Harring, 1913.
Wichita Mts.; weedy, standing pond.
Length, .26 mm.

31. *Stephanops muticus* Ehrenberg.....Fig. 33
Squatinella muticus (Ehrenberg) Harring, 1913.
Shawnee Lake; weedy, standing pond.
Length, .26 mm.

32. *Stephanops sp.*.....Fig. 35
Squatinella sp. Harring, 1913.
Horseshoe Lake; stagnant water.
Length, .21 mm.

33. *Mastigocerca capucina* Wierz. and Zach.....Fig. 34
Horseshoe Lake; plankton.
Length, .12 mm.

34. *Mastigocerca sp.*.....Fig. 36
Shawnee Lake; quiet, weedy water.
Length, .2 mm.

35. *Mastigocerca rattus* Ehrenberg.....Fig. 37
Indian Springs; clear, quiet water.
Length, .34 mm.

36. *Mastigocerca macera* Gosse.....Fig. 38
Indian Springs; quiet, clear water.
Length, .2 mm.

37. *Rattulus tigris* Muller.....Fig. 39
Trichocerca tigris (Muller) Harring, 1913.
Indian Springs; quiet, clear water.
Length, .19 mm.

38. *Rattulus cylindricus* Imhof.....Fig. 40
Trichocerca cylindricus (Imhof) Harring, 1913.
Indian Springs; Horseshoe Lake; quiet, clear water.
Length, .28 mm.

39. *Coelopus tenuoir* Gosse.....Fig. 41
Indian Springs; quiet, clear water.
Length, .28 mm.

40. *Salpina spinigera* Ehrenberg.....Fig. 42
Mytilina spinigera (Ehrenberg) Harring, 1913.
Indian Springs; quiet, clear water.
Length, .23 mm.

41. *Salpina eustala* Gosse.....Fig. 43
Mytilina eustala (Gosse) Harring, 1913.
Indian Springs; quiet, clear water.
Length, .32 mm.

42. *Diaschiza hoodi* Gosse.....Fig. 44
Indian Springs; Horseshoe Lake; stagnant water.
Length, .23 mm.

43. *Diaschiza semiaperta* Gosse.....Fig. 45
Indian Springs; stagnant water.
Length, .27 mm.

44. *Diaschiza sp*.....Figs. 46, 47
Shawnee Lake; weedy ponds.
Length, .14 mm.

45. *Dinocharis pocillum* Ehrenberg.....Fig. 48
Trichotria pocillum (Ehrenberg) Harring, 1913.
Indian Springs; clear, standing pond.
Length, .32 mm.

46. *Dinocharis tetractis* Ehrenberg.....Fig. 49
Trichotria tetractis (Ehrenberg) Harring, 1913.
Indian Springs; quiet, clear water.
Length, .33 mm.

47. *Scaridium longicaudum* Ehrenberg.....Fig. 50
Indian Springs; Horseshoe Lake; quiet, clear water.
Length, .39 mm.

48. *Euchlanis deflexa* Gosse.....Fig. 51
Ten Mile Flats; stagnant pond.
Length, .29 mm.

49. *Euchlanis macrura* Ehrenberg.....Fig. 52
Indian Springs; quiet, clear pool.
Length, .27 mm.

50. *Euchlanis uniseta* Leydig.....Fig. 53
Indian Springs; quiet, clear pool.
Length, 1.45 mm.

51. *Cathypna luna* Ehrenberg.....Fig. 54
Lecane luna (Ehrenberg) Harring, 1913.
Indian Springs; quiet, clear water.
Length, .19 mm.

52. *Cathypna leontina* Turner.....Fig. 55
Lecane leontina (Turner) Harring, 1913.
Ten Mile Flats; stagnant pool.
Length, .36 mm.

53. *Distyla ohioensis* Herrick.....Fig. 56
Lecane ohioensis (Herrick) Harring, 1913.
Wichita Mts.; rock pools.
Length, .1 mm.

54. *Distyla gissensis* Eckstein.....Fig. 57
Lecane gissensis (Eckstein) Harring, 1913.
Horseshoe Lake; quiet, clear pool.
Length, .09 mm.

55. *Distyla sp*.....Fig. 58
Lecane sp. Harring, 1913.
Ten Mile Flats; stagnant pond.
Length, .13 mm.

56. *Monostyla quadridentata* Ehrenberg.....Fig. 59
Horseshoe Lake; Ten Mile Flats; stagnant water.
Length, .28 mm.

57. *Monostyla lunaris* Ehrenberg.....Fig. 60
Horseshoe Lake; quiet, clear water.
Length, .12 mm.

58. *Monostyla bulla* Gosse.....Fig. 61
Horseshoe Lake; stagnant water.
Length, .25 mm.

59. *Monostyla sp.*.....Fig. 62
Indian Springs; quiet, clear water.
Length, .13 mm.

60. *Colurus grallator* Gosse.....Fig. 63
Indian Springs, Horseshoe Lake; clear, standing water.
Length, .12 mm.

61. *Colurus bicuspidatus* Ehrenberg.....Fig. 64
Shawnee Lake; quiet, weedy pond.
Length, .13 mm.

62. *Metopidia ehrenbergii* Perty.....Figs. 65, 66
Lepodella ehrenbergii (Perty) Harring, 1913.
Horseshoe Lake; quiet, weedy pond.
Length, .14 mm.

63. *Metopidia oxysternon* Gosse.....Figs. 67, 68
Lepodella oxysternon (Gosse) Harring, 1913.
Shawnee Lake, Horseshoe Lake, Indian Springs; weedy, standing ponds and clear pools.
Length, .11 mm.

64. *Metopidia solidus* Gosse.....Fig. 69
Lepodella solidus (Gosse) Harring, 1913.
Indian Springs, Horseshoe Lake, Wichita Mts.; cosmopolitan.
Length, .13 mm.

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EXPLANATION OF PLATES.

Plate I.

1. *Philodina roseola* Ehr. ... × 125
2. *Philodina aculeata* Ehr. ... × 63
3. *Rotifer macrurus* Schrank. ... × 125
4. *Melicerta ringens* Schrank, head. ... × 100
5. Same, head projecting from tube. ... × 33
6. *Floscularia companulata* Dobie. ... × 167
7. *Floscularia* sp. ... × 100
8. *Apsilus bucinedax* Forbes. ... × 100
9. *Asplanchna Brightwellii* Gosse. ... × 100
10. *Triarthra longiseta* Ehr. ... × 167
11. *Pedalion mirum* Hudson. ... × 125
12. *Polyarthra platyptera* Ehr. ... × 100

Plate II.

13. *Microcodon clavus* Ehr. ... × 100
14. *Copeus labiatus* Gosse. ... × 33
15. *Notommata aurita* Ehr. (from Ward and Whipple) after Weber. ... × 100
16. *Proales petromyzon* Ehr. ... × 167
17. *Furcularia forficula* Ehr. ... × 167
18. Same, toes greatly enlarged.
19. *Eosphora digitata* Ehr. ... × 125
20. *Anuraea aculeata* Ehr. ... × 125
21. *Anuraea serrulatus* Ehr. ... × 167
22. *Notholca acuminata* Ehr. ... × 125
23. *Anuraea cochlearis* var. *macrocantha* Gosse. ... × 167
24. *Pterodina patina* Ehr. ... × 125
25. *Eretmia cubeutes* Gosse. ... × 167
26. *Brachionus* sp. ... × 125
27. *Brachionus pala* Ehr. ... × 125

Plate III.

28. *Brachionus rubens* Ehr. ... × 125
29. *Brachionus angularis* var. *caudatus* Dad. ... × 125
30. *Brachionus militaris* Ehr. ... × 125
31. *Brachionus Mulleri* Ehr. ... × 125
32. *Noteus quadracornis* Ehr. ... × 125
33. *Stephanops muticus* Ehr. ... × 167
34. *Mastigocerca capucina* Wierz. and Zach. ... × 167
35. *Stephanops* sp. ... × 167
36. *Mastigocerca* sp. ... × 167
37. *Mastigocerca rattus* Ehr. ... × 125
38. *Mastigocerca macera* Gosse. ... × 167
39. *Rattulus tigris* Muller. ... × 167
40. *Rattulus cylindricus* Imhof. ... × 167

Plate IV.

41. *Coelopus tenuoir* Gosse. ... × 167
42. *Salpina spinigera* Ehr. ... × 125
43. *Salpina eustala* Gosse. ... × 100
44. *Diaschiza hoodi* Gosse. ... × 125
45. *Diaschiza semiperta* Gosse. ... × 125
46. *Diaschiza* sp., side view. ... × 167
47. Same, dorsal view. ... × 167
48. *Dinocharis pocillum* Ehr. ... × 125
49. *Dinocharis tetractis* Ehr. (from Hudson and Gosse). ... × 125
50. *Scaridium longicaudum* Ehr. ... × 125
51. *Euchlanis deflexa* Gosse. ... × 125
52. *Euchlanis macrura* Ehr. (from Ward and Whipple) after Weber. ... × 125

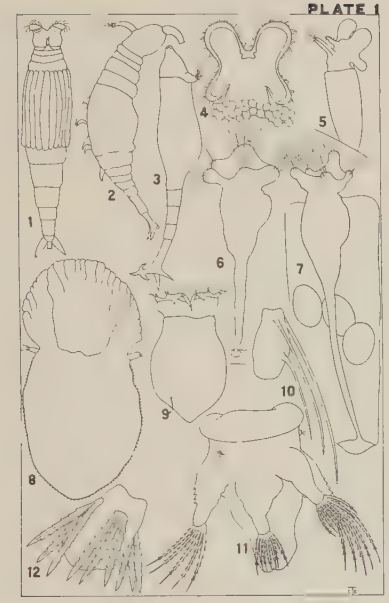
PLATE 1
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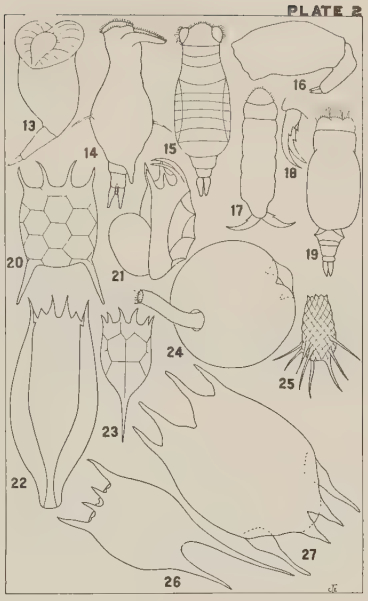
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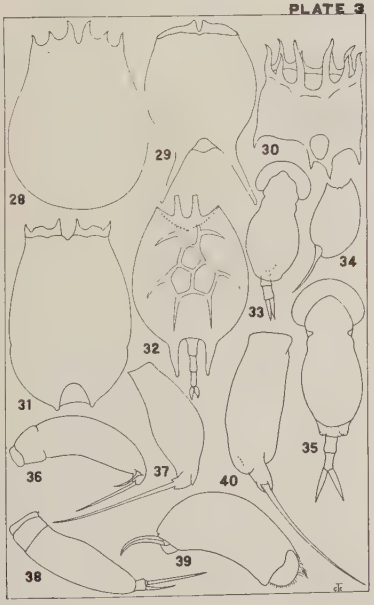
PLATE 3
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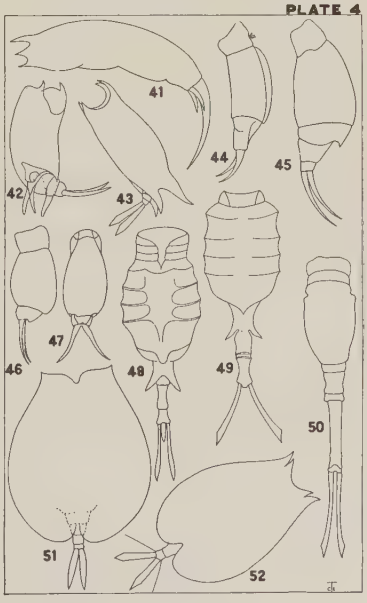
PLATE 4
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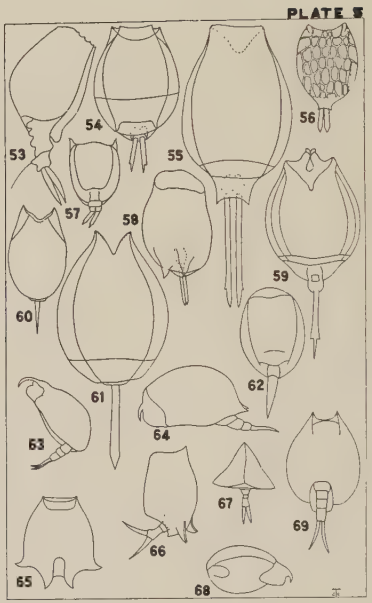

Plate V.

53. *Euchlanis uniseta* Leydig.....× 100
54. *Cathypna luna* Ehr.....× 125
55. *Cathypna leontina* Turner.....× 125
56. *Distyla ohioensis* Herrick.....× 167
57. *Distyla gissensis* Eckstein.....× 167
58. *Distyla* sp.....× 167
59. *Monostyla quadridentata* Ehr.....× 125
60. *Monostyla lunaris* Ehr.....× 167
61. *Monostyla Bulla* Gosse.....× 167
62. *Monostyla* sp.....× 167
63. *Colurus grallator* Gosse.....× 167
64. *Colurus bicuspidatus* Ehr.....× 167
65. *Metopidia ehrenbergii* Perty, ventral view.....× 167
66. Same, side view.....× 167
67. *Metopidia oxysternon* Gosse, rear view.....× 167
68. Same, ventral view.....× 167
69. *Metopidia solidus* Gosse.....× 167

THE SUBEPIDERMAL NERVE PLEXUS AND GALVANOTROPISM OF THE EARTHWORM. (LUMBRICUS TERRESTRIS LINN.)

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It is well known that the earthworm *Lumbricus terrestris* Linn. orients toward the cathode pole of direct electric current when the current is applied across a worm which is in water or on a moist surface. Moore and Kellogg (1916) explain this response as follows: "The constant current produces the effect described by increasing the tension of the longitudinal muscles on the cathode side of the worm, which results in this part being more strongly contracted than the anodal region." This is obviously a correct statement of the results, but it does not explain how these muscles at right angles to the direction of the current are made to contract on one side and not on the other.

Hyman and Bellamy (1923) in attempting to explain the same reaction say, "When Annelids are placed in a current the animals direct those parts positively charged internally toward the cathode and those parts negatively charged internally toward the anode." They do not explain, however, how a worm with a positive charge on the inside and a negative charge on the outside is made to bend toward the cathode. The reader is left to assume that there is an attraction between the negative charges of the cathode and the positive charges of the interior of the worm and vice versa.

Since the publications of the above in 1916 and 1923, respectively, Hess (1925) has described a subepidermal nerve plexus of the earthworm which might conceivably have some connection with the galvanotropic response. He has published a drawing of the subepidermal nerve plexus and the two sets of associated muscles. We have produced diagrammatically below (Figure 1) a similar drawing which shows the relations of the sensory cells to the muscles and to the central nervous system. This drawing, which is partly hypothetical, should be compared with Figures 6 and 7 of Hess (1925, p. 251 and p. 255).

To test the possible connection of the two, i. e., the subepidermal nerve plexus and the galvanotropic response, was the object of this investigation. The reasoning which led to the experiments to be described was as follows:

According to Lillie (1923, p. 276), "The stimulating action of a current is characteristically polar; i. e., the current produces its primary physiological effects chiefly at its regions of entrance and exit, and the effects at the two regions are typically opposite

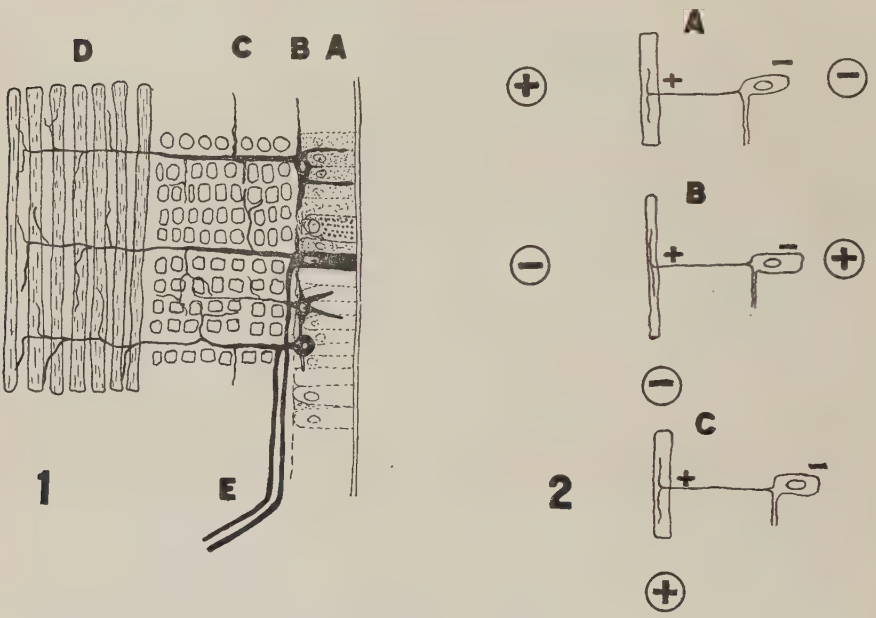

FIG. 1. Diagram illustrating the probable relation of the sensory cells in the lateral body wall to the circular and longitudinal muscles. A, epithelial layer; B, subepidermal nerve cells; C, circular muscle layer; D, longitudinal muscle layer; E, sensory nerve fibers (cut) to the nerve cord.

FIG. 2. Diagram illustrating the arrangement of electrodes in relation to the subepidermal cells and muscles. The electrodes are shown inside circles. A, the current direction, which causes longitudinal muscle contraction; B, the current direction which causes longitudinal muscle relaxation; C, the current direction which stimulates the muscles directly causing contraction.

or antagonistic. Typically, when the current is made, it initiates excitation at the cathode, (i. e., where the positive stream of the stimulating circuit passes from the tissue to the applied electrode), and inhibits activity (at the same time depressing irritability) at the anode." The above statement of Lillie is the usual form of the "Law of Polar Stimulation."

From the above it should then follow that a negative pole applied to the skin surface of an earthworm and a positive pole applied on the opposite (muscle) side should result in the stimulation of the subepidermal neurons and contraction of the circular and longitudinal muscles, provided that all traces of the ventral cord are removed. The reverse arrangement, i. e., the positive pole on the skin side and the negative pole on the muscle side should inhibit the stimulation of the neurons and relax the circular and longitudinal muscles. (See Figure 2.)

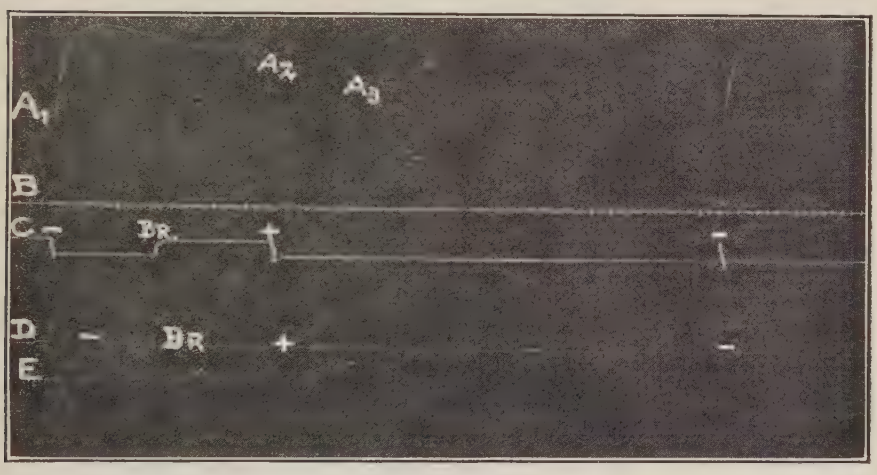

FIG. 3. Kymograph tracings which show the muscle responses under different conditions. A_1, A_2, A_3, tracing of muscle lever. The upward curve indicates contraction of the longitudinal muscles; B, time scale in seconds; C, tracing of magnet lever showing current and direction of current; D, tracing of muscle lever using narcotized tissue and direction of current; E, tracing of narcotized muscle when the current is passed lengthwise through the muscle.

APPARATUS AND METHODS.

From an earthworm that has been previously cooled in ice water a strip of lateral body wall about one and a half inches long and a quarter of an inch wide was removed. This was examined to be sure that it contained no trace of the ventral nerve cord. One end of the muscle was attached to a lever with a writing point and the other end to the bottom of a wax-lined dissecting dish. The writing point was placed against a smoked paper on a kymograph drum. Below this point was arranged a time lever and a lever connected to the reversible switch. (Figure 3, B and C.) On each side of the living strip

of body wall was placed a screen wire electrode so arranged that one electrode was parallel to the skin side and another was parallel to the muscle side. By means of a reversible switch the screen electrodes could be charged as desired. The current being derived from five dry batteries in series. Ice water was used as a conducting medium between the electrodes and the living strip of tissue. As soon as the current was made across the strip of tissue the lever registered the break or make of the current and the living strip either contracted or relaxed, making the records on the drum.

EXPERIMENTS.

Experiment 1.

In this experiment the electrodes were so arranged that the negative was on the skin side and the positive on the muscle side. The current was made registering on the drum (C—), at the same time the lever attached to the strip of tissue also registered at (A_1) showing a sudden contraction of the strip. Time is recorded in seconds at (B).

The result of the make of the current as described before is a contraction of the muscles as is shown on the graph. The current was kept going for nine and one-half seconds. The contraction of the muscle is shown by the rise of the line at (A_1). The current was then broken at the point marked Br. on the line (C). The lever attached to the tissue showed the gradual relaxation of the tissue for eleven seconds. Then the current was reversed at the point marked + on line C on the graph. The plus sign indicating that the positive electrode was at the skin side. Immediately the lever attached to the tissue showed a slight contraction at A_2 followed by a sudden relaxation. The current was kept on for forty-four seconds, thereby gradually lowering the curve (A_3) almost to the base line. Then the current was reversed again at the point marked — on curve (C) on the graph. Again the same result was registered as at (A_1).

Experiment 2.

The same strip of tissue is now allowed to soak in a very dilute solution of nicotine for four minutes. It is then taken out and attached again as in Experiment 1. The current is made at point marked — on curve (D). The current is kept on for eight seconds. The current is then broken at the point

marked Br. on curve (D) and the circuit is kept open for eight seconds. Then the current is on in reversed direction at the point marked + on the curve (D) and is kept that way for one minute. In this experiment one will notice that the curve made by the lever attached to the tissue line D was a straight line; indicating that the current had no effect whatsoever on the muscle tissue, which in the previous experiment gave clear cut results.

Experiment 3.

To the two ends of this same strip of tissue are now attached two wires in such a way that the same current can be sent through the muscle parallel to the direction of the fibres. The curve made by the lever attached to the muscle tissue in this case is the last one on the graph (E). The current was kept on for a minute and a half. The curve made by the lever in this case goes completely over the curve (D) made when the tissue was stimulated at right angles to the surface of the tissue (Experiment 2).

The results of experiments 1, 2, and 3 as detailed above are typical of five series which were carried out.

DISCUSSION OF RESULTS.

It was shown in Experiment 1 that the muscles contracted when the current was so arranged that the negative electrode was on the skin side and the positive electrode was on the muscle side, and that the muscles relaxed when the polarity of the current was reversed. Experiment 2 demonstrated the fact that when the strip of tissue which was treated with nicotine (thereby eliminating all nervous action) was at right angles to the current there was no reaction at all to the current. Experiment 3 showed that the muscles were still alive, since, when the current was run through the tissue lengthwise the muscles contracted.

This sequence of events shows by elimination that the contraction of the muscles in Experiment 1 was due to the stimulation of the subepidermal neurons and that these neurons were polarized in such a way that a reversal of the current caused not only a cessation of muscle stimulation but an active relaxation or loss of tone.

From the above it is quite clear that the neurons of the subepidermal nerve plexus control the longitudinal muscles

of the body wall of the earthworm directly and that they are electrically polarized at right angles to the surface.

The usual electrotactic response of a worm which is immersed in water can now be explained on a cause and effect basis. The longitudinal muscles on the side toward the cathode are stimulated because the polarity of the motor cells in the subepidermal nerve plexus is increased. At the same time the muscles on the side toward the anode are relaxed because the normal polarity of the motor nerve cells is decreased or possibly reversed. The two processes acting at the same time on opposite sides of the worm cause the worm to bend toward the cathode.

We are making no mention at this time of the fact that a normal worm crawls toward the cathode. The mechanism which controls this crawling is more complicated and evidently is not in any large way due to the action of the subepidermal nerve plexus.

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1923. **Hyman and Bellamy.** Biol. Bull., Vol. 43, pp. 340–343.
1925. **Hess, W. N.** Jour. Morph. and Physiol., Vol. 40, No. 2, pp. 235–259.

The Broad Field of Zoology.

This introductory zoology text is somewhat unique in that it is based on the author's belief that students should approach their study of zoology from the things with which they are familiar, and thus proceed to the aspects which are less familiar to them. With this very commendable basis, the book is built around the rat as an example of the mammals. System by system the rat is studied, with each chapter broadening out at the end into a discussion of that system in the vertebrates in general. Following reproduction are taken up embryology and heredity; following the skeletal system, locomotion; following the nervous system, animal behavior, etc. The book ends with a section on philosophical zoology, including distributional zoology, paleontology, and evolution. The impression given by the book is one of clear, well-rounded, authentic subject-matter, uniquely and practically arranged. Numerous original illustrations add considerably to the text. This book is intended as a companion volume in the elementary course to the author's earlier volume on Economic Zoology.—L. H. S.

An Introduction to Zoology, by Z. P. Metcalf. xix + 425 pp. Springfield, Ill., Charles C. Thomas, 1932.

SUPPLEMENTAL RECORDS AND NOTES ON OHIO LEAFHOPPERS.

HERBERT OSBORN,
Ohio State University.

During the two years that have elapsed since the publication of the "Leafhoppers of Ohio," with two seasons of good collecting and the assistance of Mr. E. P. Breakey, there have come to notice a number of species not entered as known to the Ohio fauna at the time of the printing of that Bulletin. Some of the species are those confidently predicted as belonging to our fauna and their collection anticipated. Some, however, were heretofore known from distant localities and their occurrence in Ohio not deemed as very probable. More detailed note of these will be given with the specific records.

This opportunity will be taken to revise certain changes in nomenclature and to correct a few errors in the bulletin which have come to notice since its printing.

Some of the additions noted serve to emphasize particularly the fact that distribution records for these insects, as indeed for many others, depend not only on intensive collecting at the proper season but especial reference to the varied hostplants and ecological habitats that support the various species.

Agallia oculata Van D. Previously recorded from Little Mt. only. This species was taken at Williams County by Mr. Breakey.

Macropsis rufocephalus, n. n. for *M. scutellatus* Osb., which name is preoccupied by the European *scutellatus* Boh. Delaware Co., June 10, 1932; Indian Lake, July 3, 1932.

Macropsis reversalis O. & B. (p. 215). Westerville, Franklin Co. (E. P. B.)

Macropsis basalis Van D. (p. 216). Westerville, Hudson, Westerville. (E. P. B.)

Macropsis trivialis Ball. Ashtabula Co., Columbus, Indian Lake.

Macropsis ferruginoides Van D. (p. 216). Westerville. (E. P. B.)

Macropsis erythrocephalus G. & B. (p. 216). Indian Lake and Rock Creek. (E. P. B.)

Macropsis sordidus Van D. (p. 217). Rock Creek, Ashtabula Co. (E. P. B.)

Macropsis nigricans Van D. (p. 217). Westerville, Franklin Co. (E. P. B.)

Macropsis bicolor Osb. Ashtabula Co. Heretofore known only from Maine.

Macropsis suturalis O. & B. Rock Creek, Ashtabula Co., June 24, 1931.
Macropsis tristis Van D.—Nymphs (p. 217). Rock Creek, Ashtabula Co., June 24, 1931, 2 P. M.
Macropsis insignis Van D. Ashtabula Co.
Macropsis osborni Breakey (Ms.)* Descriptions from Ohio specimens taken at Arcanum. (O. H. S.)
Macropsis cinerea Breakey, (Ms.).† Descriptions from Ohio specimen taken at Indian Lake. (E. P. B.)
Xerophloea majesta Lawson. Clermont Co., 9–15, J. M. Robinson. Similar to *major* Baker in the broad head.
Acocephalus flavostriatus Columbus (M. V. Anthony). Previously recorded for New York.
Xestocephalus coronatus O. & B. One specimen, Nettles Lake, Williams Co. (E. P. B.) This handsome little species was described from a specimen taken in Iowa and this Ohio specimen is the only other record that I know.
Xestocephalus brunneus Van D. Additional records are Columbus, Williams Co., Ashtabula Co., on Black Locust. (E. P. B.)
Scaphoideus melanotus Osb. Holgate, Logan Co., July 14, 1931. (Anthony).
Platymetopius cuprescens Osb. Adams Co., August 31, 1931. (H. O.) Previous records are for localities east of the Allegheny Mountains. Mr. Breakey took specimens of this species at Dune Park, Indiana, which carries the distribution still farther west.
Eutettix southwicki Van D. (p. 300). Brown Fruit Farm, Delaware Co.
Eutettix lurida Van D. Williams Co. (E. P. B.)
Novellina helenae Ball, Columbus—similar to *chenopodii* Osb., but smaller and with different picture.
Stirellus obtutus Van D. Rockbridge, Hocking Co., October 2, 1931. (H. O.) Taken at the E. S. Thomas shack.
Phlepsius incisus Van D. (p. 311). Brown Fruit Farm, near Worthington, August 15, 1931. (E. P. B.)
Phlepsius pusillus Baker (*collinus* O. & L.) Adams Co. (H. O.)
Phlepsius punctiscriptus Van D. Lynx and Hachelshin Ridge, Adams Co. (H. O.) Hocking Co. (E. P. B.)
Phlepsius majestus O. & B. Near London, Madison Co. (H. O.) September 7, 1931, Hocking Co. (E. P. B.) and, at light, Silver Lake, Bellefontaine, Logan Co., by D. J. Borror. Previous records for Columbus only.
Thamnotettix collaris Ball (p. 321). Taken at the Urbana bog, Champaign Co.
Paracoelidea tuberculata Baker. Rockbridge, Hocking Co. (E. S. Thomas shack), October 2, 1931. (E. P. B.) Previous records are from pine at points east of Appalachian divide.
Empoasca erigeron DeLong. Recorded by Dr. DeLong for Columbus.
Empoasca infusca DeLong. Described by DeLong as from Columbus, Canal Winchester, Worthington and Carroll.

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*To appear in Annals Ent. Soc. Amer.
†To appear in Annals Ent. Soc. Amer.

Empoasca bifurcata DeLong. DeLong gives the range of this species as Wisconsin to Northern Pennsylvania and south, so it no doubt occurs in Ohio.
Typhlocyba gillettei var. *sincera* McAtee. Ashtabula Co.
Typhlocyba gillettei var. *casta* McAtee. Columbus (H. O.) Madison Co.
Typhlocyba nitidula (Fals.). Ashtabula Co. (E. P. B.)
Typhlocyba nitidula var. *norgueti.* Ashtabula Co. (E. P. B.)
Typhlocyba pulchella McAtee. Ashtabula Co. (E. P. B.)
Typhlocyba phryne McAtee. Ashtabula Co. (E. P. B.)
Typhlocyba antigone McAtee. Madison Co. (E. P. B.)
Typhlocyba appendicula Mall. Williams Co. (E. P. B.)
Typhlocyba rubriocellata Mall. Franklin Co. (E. P. B.)
Typhlocyba cymba McAtee. Little Mt., Lake Co.
Erythroneura mediana Rob. On Elm, Columbus. (H. O.)
Erythroneura beameri Rob. Franklin Co. (E. P. B.)
Erythroneura pulchella Rob. Adams Co. (E. P. B.)
Erythroneura rubra Gill. Adams Co. (E. P. B.)
Erythroneura tricincta var. *diva.* Columbus. (H. O.)
Erythroneura tricincta var. *cymbium.* Franklin Co.
Erythroneura tricincta var. *integra.* Franklin Co. (E. P. B.)
Erythroneura tricincta var. *calycola.* Adams Co., Franklin Co., and Madison Co.
Erythroneura trivittata Rob. Madison Co. (E. P. B.), W. Jefferson, Franklin Co. (H. O.)
Erythroneura torra. Williams Co. (E. P. B.)
Erythroneura abolla McAtee. In Ohio on Honey Locust. (H. O.)
Erythroneura brundusa Rob. Marietta, Oxford. (H. O.) On Honey Locust, Franklin Co. (E. P. B.)
Erythroneura crevecouri Gill. Additional record, Columbus.
Erythroneura minor Beamer. Recorded for Camp Perry by McAtee.
Erythroneura scripta Rob. Franklin Co. (E. P. B.)
Erythroneura lacta Rob. Franklin Co. (E. P. B.)
Erythroneura amanda McAtee. Adams Co. (E. P. B.)
Erythroneura osborni DeLong. Previous record on mistaken identification.
Erythroneura sp. Not *osborni.*
Erythroneura aclys McAtee. Mistaken identification.
Erythroneura sp. Like *aclys*, but with different picture.
Erythroneura portea Rob.
Erythroneura ligata McAtee. Perry Co. (McAtee). Columbus, May 19, 1928. (H. O.)
Erythroneura vitis var. *stricta* McAtee. Perry Co.
Erythroneura comes var. *rubra* Gillette. Perry Co. (McAtee).

Some very interesting records have been secured by Mr. Virgil Argo from collections made at trap lights on the A. I. U. tower in Columbus. These traps placed at an elevation of 425 feet above street level were run for a number of nights during the summer of 1931 and samples of the leafhopper catch were submitted to me for study. These represented collections made

from June 21 to July 7 and the species and distribution is shown in the following table. The numbers indicated refer only to the number in the samples examined and cannot be taken as a quantitative measure of the relative abundance except in a general way they must indicate the species that were most numerous in the drift of insects going, mainly with the wind, at this distinctly elevated station.

TABLE I.

LEAFHOPPERS AT LIGHT, A. I. U. TOWER, JUNE AND JULY, 1931, 425 FEET ABOVE STREET.

	June 21	June 22	June 23	June 24	June 25	June 27	June 29	June 30 July 4	July 5–6	July 7
Cicadellidae										
Idiocerus pallidus							1			
Idiocerus suturalis								1		
Idiocerus scurra	1									
Macropsis sp.						1				
Macropsis sp.							3	2		
Bythoscopus apicalis						1				
Draeculacephala mollipes	1			2				2		
Draeculacephala sp.								2		
Gypona octolineata										1
Xestocephalus pulicarins						1	1		9	
Xestocephalus sp.?							1?			
Platymetopius frontalis			1				1			
Platymetopius hyalinus								1		
Scaphoideus nigricans								1		
Scaphoideus immistus										1
Deltocephalus inimicus	130	6	50	56	15	21	20	15	20	12
Deltocephalus flavicosta				1						
Euscelis obscurinervis										1
Eutettix seminudus	1					1		1		1
Phlepsius irroratus		1	1	2		2	8	13	1	3
Phlepsius collitus							1			
Thamnotettix nigrifrons							1			
Thamnotettix inornata								1		
Chlorotettix unicolor								1		
Chlorotettix viridius										1
Chlorotettix spatulatus								1		
Chlorotettix galbanatus										

TABLE I—Continued.

	June 21	June 22	June 23	June 24	June 25	June 27	June 30	June 30 July 4	July 5–6	July 7
Cicadula punctifrons			1	1						1
Cicadula sex-notata	1		1							2
Cicadula sp.?										1
Eugnathodus abdominalis										1
Dikraneura sp.						1				
Dikraneura sp.						1				
Empoasca fabae?		3		4	2	3	3		4	1
Empoasca obtusa?		2								
Empoasca sp.?										
Typhlocyba gilletei var.							1			1
Typhlocyba sp.		1	2			1	1			
Typhlocyba sp.							1			
Erythroneura sp.?										1
Membracidae										
Cyrtolobus								1		
Atymna castanea								1		
Micrutalis calva			1							
Fulgoridae										
Cedusa incisa								1		
Stobaera tricarinata								1		1
Liburniella ornata						1				
Delphacodes propinqua?				1						
Aphididae sps.?			1			1				

It will be noted that *Deltocephalus inimicus* was most numerous and in the catch of every night from June 21 to July 7. *Phlepsius irroratus* was second and represented in all catches except June 21 and 25.

These records indicate extended migration and wide dispersal as well as attraction to light and ability to reach higher strata of air. Some of the species included are rarely taken in collecting; some of them doubtless arboreal and out of reach for ordinary sweepings. Many are willow feeding, some oak and many grass with range from Xerophytic to Hydrophytic in habitat.

NATIONALISTIC ELEMENTS IN FARMING ON THE LAKE PLAINS OF NORTHWESTERN OHIO.

CARL DUDLEY VARVEL,
Ohio State University.

NATIONALISM.

The population map for Ohio shows that the rural population of Northwestern Ohio is well distributed. (Pl. I, Fig. 1.) The density of population averages for this area 60 per square mile, compared with 163 per square mile for the entire state and 42 per square mile for the United States.

A cursory examination of family names indicates that in the towns and villages the population is well mixed so far as the national origin is able to be identified. Biological mixing occurs more readily in urban areas than in rural areas. In the latter there is evidence of the persistence of nationalistic homogeneity where for example German marries with German, Pole with Pole or Old American with Old American. This may be due either to geographical propinquity or social inertia in choosing the marriage path of least resistance, but the consequences are that certain traits of nationalism are continued and accentuated.

LAND VALUES AND SETTLEMENT.

The Lake Plain counties are rich farming lands. Eleven counties of Northwestern Ohio which compose it in whole or in part contain about 9% of the area of Ohio, yet they hold about 18% of the farm wealth of Ohio. Land values in four counties—Wood, Henry, Putnam, and Paulding, whose soils are almost wholly composed of lacustrine sediments, were appraised on April 1, 1930, at an average of $104 per acre, which was 25% higher than the average farm value for Ohio. This was the last extensive area of Ohio to be occupied by the pioneer. The swampy character of these plains of low relief (Fig. 2) retarded settlement as long as better lands were available.

LAND USE.

These lands are normally devoted to a regime of mixed grain farming associated with the raising of livestock and poultry. Corn, oats, wheat, soybeans and alfalfa are the principal cultivated crops and are everywhere grown in rotation. In addition 90% of the sugar beets grown in Ohio are produced here. Relative proximity to Toledo and Detroit, thanks to numerous hard surfaced highways and speedy motor trucks, has stimulated truck farming and market gardening. Sandy well drained soils of the old lake beach ridges (Fig. 3) favor vegetable cropping on a large scale. (Fig. 5.) Owing to the tempering influences of the cool lake waters, fruit trees escape the hazards of early budding. Specialized fruit culture, particularly as related to apples, peaches, and grapes, is highly successful on the lake peninsula of Ottawa county—the Port Clinton area—as well as on the valley slopes of the Upper Maumee River. Practically every general farm has an orchard which supplies domestic needs.

THE PIONEERS.

The first efforts made by Europeans and their descendants to occupy the territory in any capacity were made by the French trappers and traders in 1680. English traders began to establish themselves in opposition to the French about 1700.* The earliest farmers were doubtless the descendants of the French and English trappers. Some farmers of Yankee and other old stocks filtered into the area in the decades after the Revolutionary War as part of the "Westward Movement." The well drained lands of the beach ridges were the first to be settled for most of the area was of a swampy nature and heavily wooded.

In the year 1820 the population of the "Lake Plains Counties" was too small to be counted in the decennial census. By 1830 the "Swamp land" Counties—Wood, Henry, Paulding and Putnam—contained less than two thousand persons. In 1860 these contained nearly 45,000 inhabitants. In 1930, a century of population growth showed that these counties contained 113,219 inhabitants. Such population figures indicate that settlement was rapid once the movement for land improvement was started.

*Knapp: History of Maumee Valley. Toledo, 1877, p. 10.

THE GERMANS.

The traveler is likely to be impressed by the large number of people bearing names of obvious German origin. Germans began migrating to Northwestern Ohio at a rather early date. The first settlement in Fulton County was made in German Township in 1834 by a group of Amish Mennonites from Mülhausen in Alsace. The farm lands of this same township in 1932, nearly a century later, are owned almost exclusively by the thrifty descendants of these pioneers. One community leader* said that there is not a farm mortgage in the township. German Township is one of the best corn producing areas of Ohio and is locally noted for the feeding of swine and beef cattle.

The first recorded German settlement in Wood county was made in Perrysburg township in 1852 by a group of Roman Catholic families from Munich in Bavaria. The families were large and the settlement prospered. One historian has said, "They deserve especial credit for they came before the improvement of lands had begun." Other groups of German people came during the decades before and after the Civil War, many from abroad and others principally from German settlements in Pennsylvania.

These German migrants coming into the area later and with meager funds found the unoccupied swampy lands for sale at a relative low price, since the presence of timber and swamp vegetation precluded their use for agriculture. However, these poor lands offered an advantage, for unlike the forested lands encountered by the pioneers in southern and central Ohio, there was a market for timber. Many local hoop mills and stave factories consumed both elm and oak lumber. The shipyards at Toledo bought readily the larger and finer trees of oak.

The German pioneers, as well as others, had a common method of attacking the problem of land clearing and drainage. In general a pioneer bought a few acres of forested land from the state, cleared and drained an acre or two the first year and planted a crop as soon thereafter as possible. With the money received from the sale of the timber, he bought a few more uncleared acres and improved them. He used the proceeds from the sale of the timber and foodstuffs to extend and improve his land holdings.

*A newspaper editor at Archbold, Ohio.

The German farming people were derived generally from the tenant agricultural classes of "The Fatherland." They knew by experience the conditions of hard physical work, long hours of toil, self denial of many things and too, necessary thrift. As a race of pioneers they brought much in physical and mental energy which has been inherited by their descendants. They knew the soil intimately because of the practices of hand-and-knee labor in the homeland. Constant fertilization of soil was not scoffed at by those whose forbears for hundreds of years had been farmers. "Long hours of labor were joyous when they felt certain that it would bring a money reward and as well the pride of land ownership," one of them said to the writer.

Their religion, either Protestantism or Roman Catholicism, taught humility and simplicity in the daily needs, for they of recent European origin had long believed themselves to be destined for a lowly place in society. Religion taught, especially to the Amish Mennonite, a positive injunction against the display of wealth in costly clothes, "showy" furniture, spirited horses or other elements of culture displayed by others. These German folk could without pain put the profits of the farm back into their lands. They built them up until today many of them are model farms and in ordinary times bring more than average financial returns.

In contrast, other farmers of non-Germanic stock are reported to have followed the practice of taking the profits away from the lands until their holdings of similar physical structure have become of nearly marginal productivity. As marginality acts, the German farmers are frequently in a position to purchase these lands and subsequently restore them to productivity of a higher order.

A widespread characteristic among the German farmers as among successful farmers everywhere is the work-plan for doing the repair job needed to be constantly performed on any farm. Among them it is axiomatic to put aside such repair work to be done indoors, such as harness, tool and implement repair, until a rainy day prevents outside labor. Other farmers it is averred, make no definite programs, hence on rainy days when the Germans are accomplishing their repair jobs, the village loafing places are often crowded by farmers of other nationalities.

From observation one can say, and not untruthfully, that nine out of ten neat farmsteads are owned by German farmers, or that nine out of ten sloven farmsteads are not German farmsteads. Characteristic of German farms are well kept, spacious farmhouses, well planted and cropped yards (Fig. 6), large barns well designed and constructed, for the storage of hay and machinery and for feeding indoors large numbers of cattle. (Fig. 7.) The barns generally are painted white with the owners name in large letters conspicuously displayed. The farmyards are in most cases gravelled and clean enough to accommodate a picnic dinner at anytime without offense. The fences and gates reveal an air of farm prosperity. These conditions are not exclusive among the German farmers but are characteristic of them.

POLES.

Polish farmers of the Lake Plains of Northwestern Ohio are found today largely in "the Oak Openings." The "opening" is an area of predominantly sandy surface material which lies west of Toledo in the southwestern part of Lucas County. It extends into southern Fulton County and into northeastern Henry County. It is a heterogenous growth of flora associated with the oaks, generally infertile in an agricultural sense, cleared and kept cleared with difficulty (Fig. 9). It is a land which supports a bare subsistance economy. Most of the Polish people living on these lands are there not because of any special farming ability they may possess, but because economic conditions have repelled them from the urban industries. A few acres of this land offered something of a refuge. The Poles are handicapped in several ways; the land is inferior and the competition of the Germans on the better lands creates an economic hardship from which there is little relief. These Polish people support large families which offer much potential farm labor. With the handicap of infertile land this labor cannot be employed to any special productive advantage. The large family is a consuming family and possibly accentuates the poverty induced by the land.

At most the "Oak Openings" provides very poor pasturage, and equally poor cereals. There is the culture of some melons, berries, grapes and little else. Commercial vegetable cropping has not been satisfactory due to competition of the better

lands. Farm buildings (Fig. 8) seem to reflect the poor quality of the land and holdings are pitiably small in contrast with those of the Germans.

SWISS.

There are notable German Swiss settlements in Putnam County, largely on the Lake Plain. These include prosperous people who have built their lands to a high degree of productivity. The teachings of the Mennonite Church have shown a marked influence here as in German Township in Fulton County, already mentioned.

OLD AMERICANS.

Yankee and other Old American peoples are generally distributed throughout rural northwestern Ohio, but they seem to be less common than those folks of German origin. It is safe to suggest that many of these older peoples have moved from the worn out lands to newer and better lands while others have felt the call to the cities where wages and salaries appealed more than the land. It must be said, however, that many of the descendants of these old families are today eminently successful farmers where they have pursued the methods used by the Germans.

CONCLUSIONS.

From these observations it seems evident that among those people of known national origins in this widespread farming area certain elements have played a conspicuous part in its agricultural development. The inherently good qualities of the German farmer as a soil manager, his willingness to work long hours, the fertility of the newly drained soils, the early initial advantage of the sale of the timber and the good market for the sale of agricultural products have all combined to make his position a secure one and his contribution to agricultural advancement not only of local importance but of value to the state.

EXPLANATION OF PLATE.

FIG. 1. Population Map of Northwestern Ohio, by Guy-Harold Smith. Courtesy of the Geographical Review, published by the American Geographical Society of New York. The dotted line represents the shores of glacial Lake Maumee, after Leverett, Monograph 41, U. S. G. S. pp. 50–51. The map indicates the uniformity of rural distribution.

FIG. 2. The Lake Plains comprise thousands of acres of land of distinctly low relief.

FIG. 3. The "beach" of ancient glacial Lake Maumee rises gradually from the "lake" floor. It is the site of highways and many farm houses.

FIG. 4. Large drainage canals near Lake Erie are necessary. Capillary water which threatens the farm lands is pumped constantly into these channels.

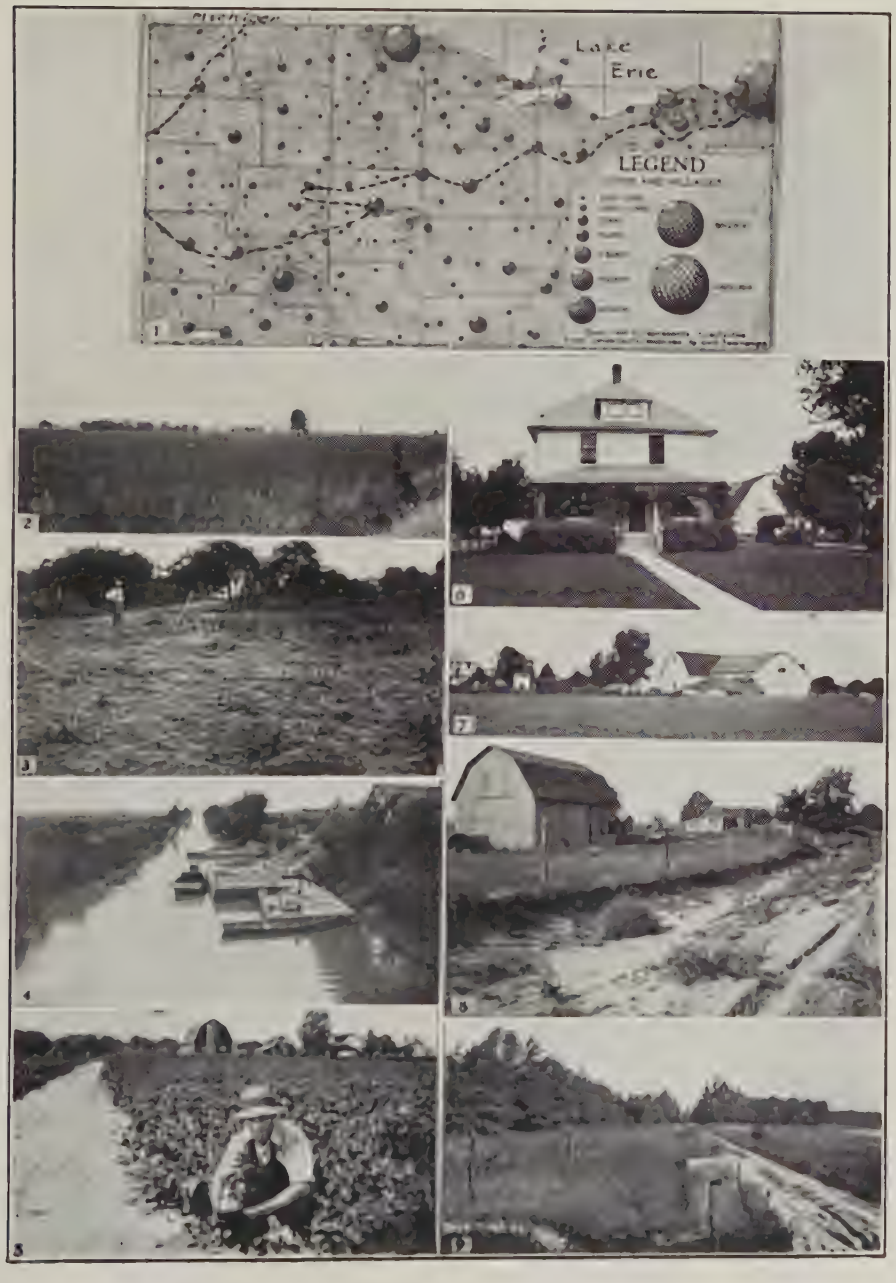
FIG. 5. Commercial vegetable growing is characteristic of the sandy soils. (The photo shows a portion of a field of eggplant.)

FIG. 6. Buildings on most "German-owned" farms carry an air of neatness and reflect thrift. Well planted yards and lawns are common characteristics.

FIG. 7. Most German farmsteads are well arranged. (The house is shown in Fig. 6.)

FIG. 8. The farmsteads in the "Oak Openings" are indices of the relative poverty of the soils. These farmsteads are in striking contrast with those of the better lands.

FIG. 9. Most of the arable lands in the "Oak Openings" are used for pastures which ordinarily have a low "carrying capacity."


Lake
Erie
LEGEND

SOLUTION PHENOMENA IN THE BASAL ONEOTA DOLOMITE.

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The systemic contact between the Cambrian and Ordovician formations in the upper Mississippi valley occurs between the Jordan sandstone and Oneota dolomite, of Cambrian and Ordovician age, respectively. An erosional unconformity at this contact is suggested by a red residual clay zone, present at places along the contact, and to irregularities in the normal bedding of the sandstone and dolomite.

The red clay is not always present below the dolomite, but is developed where evidence of solution of the dolomite is found. The Oneota is strongly jointed from the present surface to its base. Effect of solution along the joints is shown by the smooth, rounded, and somewhat undulatory joint surfaces and also by the concentration of iron oxide and clay so frequently found coating the surface of the dolomite in these channelways.

The joints are now filled with silt and sandy silt which very closely resemble the clastic material occurring immediately below the dolomite. The bedding in the joint filling material bends downward at the walls of the joints in the lower portion of the openings but no structure occurs in these fillings in the higher portions of the joints. The clastic material below the dolomite is deformed in many of the outcrops, the greatest deformation is below the zone of most intense jointing. At these places the undeformed stratification of the sandstone can be followed beneath a large joint where striking re-entrant angles have been formed by solution widening at the bottom of the joints. These re-entrants frequently penetrate the dolomite several feet. The otherwise horizontal bedding planes arch into such joints in miniature anticlines which show squeezing on the flanks with thickening at the axes. Material from the axes is clearly squeezed upward into the joints for considerable distances. Figure 2 illustrates the deformation of the clastic material at the base of a joint where solution has enlarged it. The Oneota is invariably broken and disturbed by settling where these clay and sandstone re-entrants and joint fillings occur, the intensity and size of the fractures in

the dolomite is proportional to the squeezing displayed in the sandstone.

Winchell and Upham* noted these irregularities at the base of the dolomite at numerous points along Minnesota river and its tributaries. They suggested downward migration of Cretaceous clays and silts along joints in the Oneota during Cretaceous time and assumed the clays were then carried into widespread solution cavities at the base of the Oneota where the stratification developed in these clays conformed to the shape of the openings.

FIG. 1. Southern Minnesota. Numbers indicate location of sections studied in detail.

The numerous joints in the Oneota dolomite furnished excellent channels for downward flowing waters. On reaching the sandstone the waters spread laterally, developing small solution cavities at the base of the dolomite over rather extensive areas. This phenomenon would be especially developed at a time when the level of the groundwater table closely approached the contact plane between the two formations. The top of the Jordan, shown in Figure 2, is a fine-grained water-bearing sandstone. The fineness of the texture even at

*Upham, Warren: Geol. and Nat. Hist. Surv. of Minn., Vol. I, pp. 432–438, 1872–1882.

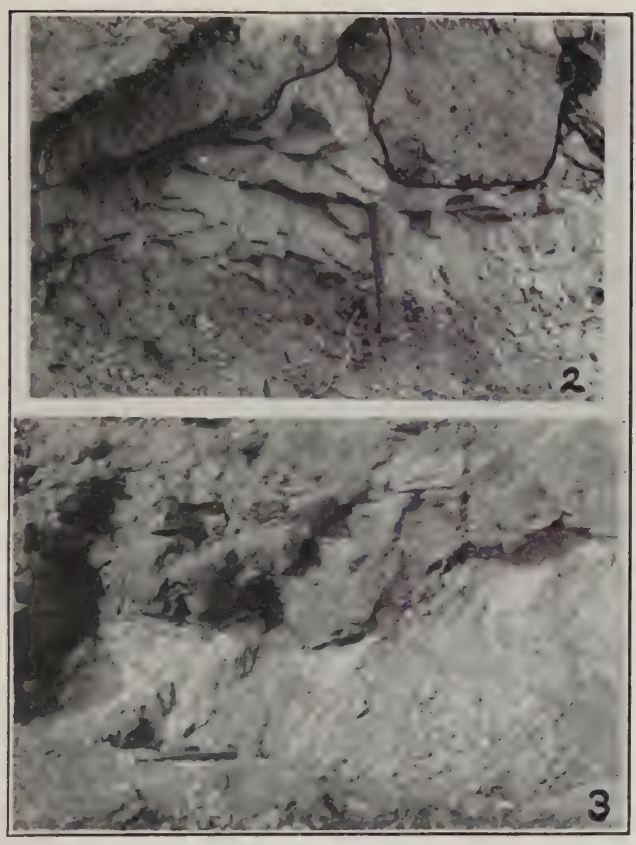

FIG. 2. Deformation of the fine-grained clastic material by solution and settling of the overlying Oneota dolomite. Penetration of the folded bed into a joint plane is well shown. Silbey Park, Mankato, Minn.

FIG. 3. Solution and settling of the Oneota has resulted in deformation of the underlying clastic material. Exposure at St. Peter, Minn.

present causes the water to be held for some time after the coarser underlying layers are dry. Water passing downward along the joints in the Oneota is slowed up in its downward motion on reaching this fine sandstone, resulting in lateral spreading, giving rise to the conditions necessary for the accomplishment of the observed solution effects. In Figure 3 the relationship between a medium-textured phase of the Jordan in contact with the Oneota is shown. The sandstone is massive, thus masking the irregularities in the bedding planes although the irregular re-entrants at the contact are very well developed. Downward moving waters would not be slowed up under such conditions on reaching the sandstone unless the groundwater table roughly coincided with the contact of the sandstone and dolomite. Since extensive solution did occur under this condition the above relationship is assumed to have existed at some time prior to the settling of the dolomite into its present position.

As solution progressed the sandstone below was deformed and squeezed into its present position by settling of the dolomite due to irregular sinking of the unsupported and weakened portions. In some cases the sandstone has been forced 15 to 20 feet upward along the joints in the dolomite, at times it no doubt was forced even greater distances upward, but erosion has removed the higher beds so no greater measurements were secured. It is assumed that settling of the dolomite approximately kept pace with solution, preventing accumulation of irregular dolomite blocks on the floor of the caverns, since no such blocks have been found. The deformation of the very fine-grained friable sandstone or silt zone at the top of the Jordan is expressed by an irregular series of small folds definitely showing thinning on the flanks with thickening along the axes. These folds have their axes under joints in the dolomite which have been filled by the injection of the sandstone during the period of settling of the blocks. On the highway from Mankato to New Ulm, a short distance out of Mankato, maximum deformation of the Jordan was observed. Here the Jordan has been squeezed into folds 10 to 15 feet high. At this locality the Oneota shows the effect of fracture and settling very clearly by the great disturbance in the normal bedding.

At several localities, Stillwater, Ottawa, St. Peter, Mankato, and numerous places noted by Winchell and Upham, concentrations of iron oxide and clay ranging in thickness from a

fraction of an inch to several inches occur beneath the dolomite and along the walls of the numerous joints. This concentration of iron oxide and clay suggests circulation of ground water which dissolved the dolomite along these joints and at the contact of the dolomite and underlying clastics. It is not thought that these concentrated materials indicate a residual accumulation on an ancient land surface since they not only occur at the base of the dolomite but also along the edge of joints widened by solution.

Solution of this sort would result in a concentration of the residual minerals of the Oneota on the top layer of the Jordan sandstone. At one locality, Ottawa on Minnesota river, such a concentration occurs.

The time during which the Oneota settled into the upper Jordan can not be definitely stated, but was no doubt when the competency of the dolomite was low. Settling occurred either when sufficient reduction in thickness of the poorly supported formation was accomplished, or when the added weight of one of the Pleistocene ice sheets increased the load beyond the strength of the weakened formation. It is thought that the settling took place in Tertiary or post-Tertiary time, but no evidence can be presented in support of such a view other than a theoretical consideration of the thinning necessary for failure of the formation.

Heredity in Man.

A British biologist presents in this volume a most interesting and valuable account of the applications of genetic principles to man's welfare. The determination of the type of inheritance involved in human characters is not at all the relatively simple problem which it proves to be in many plants and animals. Methods for such determinations in man are presented and discussed. The possibilities and limitations involved in the mapping of human chromosomes are touched upon. Twins and their bearing on problems of human heredity are taken up with a precise analysis of existing material. Races, populations, and social groups are all subjected to the same genetic analysis, with the result that some of the older orthodox "rule-of-thumb" genetic pronouncements are severely shaken.—L. H. S.

Genetic Principles in Medicine and Social Science, by Lancelot Hogben. 230 pp. New York, Alfred A. Knopf Co., 1932.

OBSERVATIONS ON SEMI-DESERT ANTS.

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I. Early Spring Temperatures of Ant Mounds in the Sagebrush Semi-Desert.

The two most prominent ant mounds in the sagebrush semi-desert area of southern Idaho are those of *Pogonomyrmex occidentalis* Cresson and *Formica rufa obscuripes* Forel. They occur in great abundance at Twin Falls, Idaho, those of the former scattered and those of the latter grouped. The collection of temperature data was begun on March 21, the first calendar day of spring.

In early spring the interiors of mounds of *P. occidentalis* are only slightly warmer than the exteriors. This is particularly true of mounds composed entirely of pebbles which do not tend to absorb heat as rapidly as do those of detritus. Temperature varies with depth, being higher toward the surface of the mound and lower with descending progression. The highest temperatures occurred at a depth of approximately four inches and the lowest at eighteen. Temperatures at various depths in an average sample of each type of mound are shown in Table I and Figure 1. The air temperature at the time of these measurements (2 p. m.) registered 40 degrees Fahrenheit. Note the gradual decrease in temperature at increasing depths below four inches. This partly accounts for the fact that in early spring the majority of ants of this species are situated at the optimum temperature level of about four inches.

Formica obscuripes is the first ant to become active in the early spring in the vicinity of Twin Falls. It builds dome-shaped mounds of sticks and leaves which are generally formed around large plants of sagebrush (5). Figure 2 illustrates typical mound temperatures on March 31, 1932. Note the contrast between temperatures within the mounds and those of adjacent soil. The highest mound temperature obtained was 80 degrees Fahrenheit and occurred six inches below the mound surface. There was a decided drop in temperature

between the six and the two inch level. The temperature of adjacent soil, on the other hand, was slightly higher at two than at six inches and there was a marked increase from the two-inch level to the soil surface. At the time these temperatures were recorded (11 a. m.) the air temperature in the shade registered 68 degrees Fahrenheit and 70 degrees in the sun. The surface temperature of the shady face of the mound was recorded as 80 degrees and that of the sunny face as 94 degrees.

TABLE I.

Typical Early Spring Temperatures of Mounds of *Pogonomyrmex occidentalis* at Various Depths.

Depth	Temperature Pebble Mound	Temperature Detritus Mound
0 inches	36.5 F.	36.5 F.
2	37.0	37.8
4	38.0	39.5
6	37.5	38.2
8	36.0	36.4
10	36.0	36.0
12	35.3	35.4
14	33.6	33.1
16	32.2	32.2
18	32.0	32.1
20	32.1	32.2

The faces of mounds of both species attain higher temperatures than does the adjacent soil surface because the rays of the sun on the faces are more intense than on a like area of soil surface. This point is diagrammatically illustrated in Figure 3. Only when the sun is directly overhead are its rays, directed upon both the mound and adjacent soil, of equal intensity. During the greater part of the day one face of the mound tends to lie more or less perpendicular to the sun's rays, while the rays are more dispersed on the level soil adjoining the mound.

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(2) **Idem.** "Sequential distribution of Formica exsectoides Forel." *Psyche*, 1926.
(3) **Cole, A. C., Jr.** "The ant, Pogonomyrmex occidentalis Cr., associated with plant communities." *Ohio Jour. Sci.*, XXXII (1932), 10–20.
(4) **Idem.** "The relation of the ant, Pogonomyrmex occidentalis Cress., to its habitat." *Ohio Jour. Sci.*, XXXII (1932).
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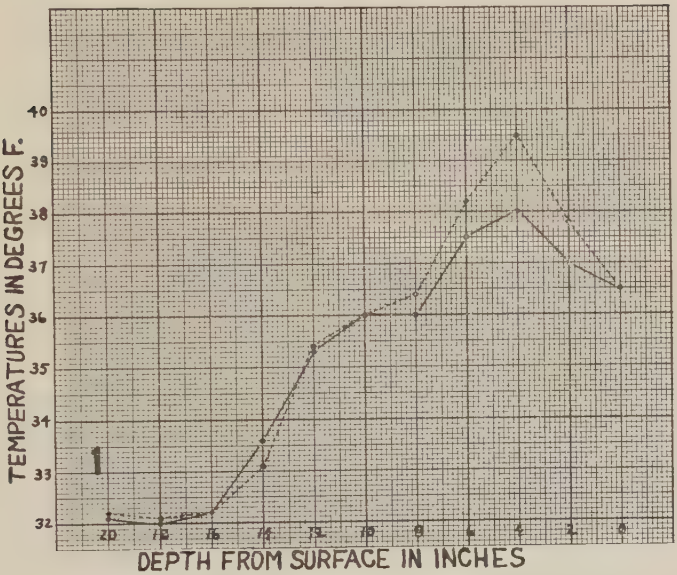
(6) **Field, A. M.** "Temperature as a factor in the development of ants." *Biol. Bull.*, IX (1905).



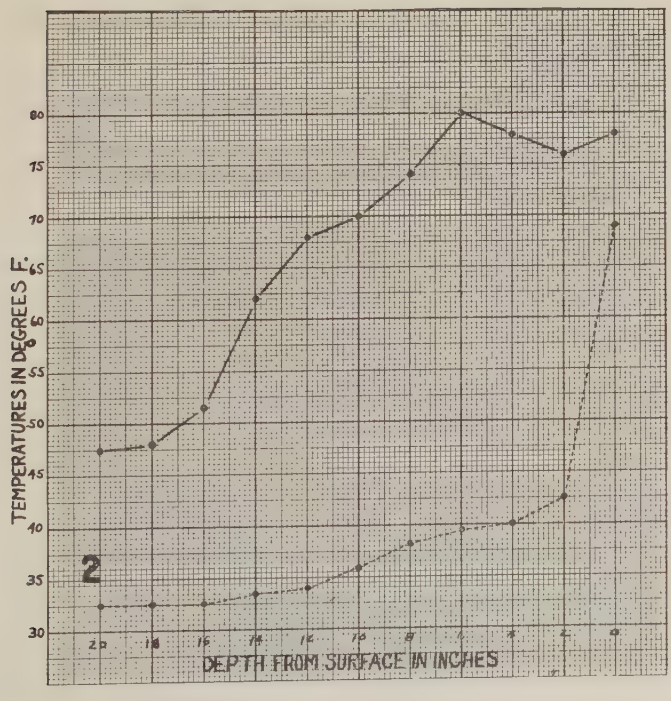


FIG. 1. Typical early spring temperatures, at various depths, in mounds of *Pogonomyrmex occidentalis*. The solid line represents temperatures of a pebble mound and the broken line those of a mound of detritus.

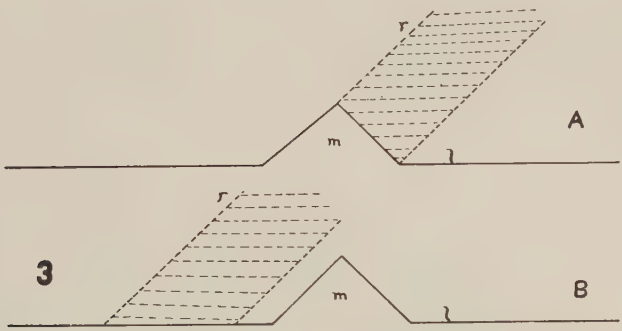
FIG. 2. Typical early spring temperatures of a mound of *Formica rufa obscuripes* and an area of adjacent soil. The solid line represents temperatures of the mound and the broken line those of the adjacent soil.

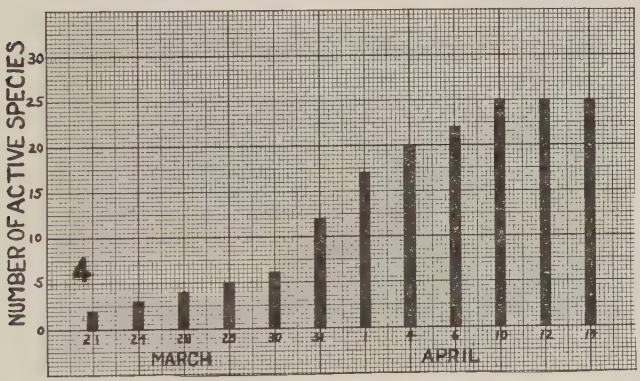
II. Increase in Early Spring Activity of Semi-Desert Ants.

Observations on the increase in the number of species of ants becoming active from the first calendar day of spring to the middle of April, 1932, were made by the writer in the Twin Falls Area, Idaho.

On March 21 two species of ants were decidedly active in this section, namely, *Formica rufa obscuripes* Forel and *Tapinoma sessile* Say. The temperatures within the detritus mounds of *F. obscuripes* were much higher than the prevailing atmospheric temperatures, (Part I of this paper; also reference (3)). *Tapinoma sessile*, on the other hand, is one of our most hardy ants and is quite active even under low temperature conditions. On March 24 the Occident Ant (*Pogonomyrmex occidentalis* Cresson) began activity and removed the grass coverings from its pebble mounds. March 28 marked the initial date of early activity of *Lasius niger americanus* Emery; March 29, of *Formica subpolita* Mayr; March 30, of *Formica fusca subsericea* Say; March 31, of *Lasius umbratus mixtus aphidicola* Walsh., *Formica neogagates neogagates* Emery, *Camponotus hyatti* Emery, *Leptothorax curvispinosus rugatulus* Emery, *Crematogaster lineolata* Say, and *Monomorium minimum* Buckley; April 1, of *Formica sanguinea puberula* Emery, *F. cinerea neocinerea* Whlr., *Solenopsis molesta validiuscula* Emery, *Myrmica rubra scabrinodis* Nyl., and *Myrmecocystus melliger semirufus* Emery; April 4, of *Leptothorax melanderi* Whlr., *Iridomyrmex pruinosus* var., and *Myrmica sp.;* April 6, of *Myrmica mutica* Emery and *Brachymyrmex sp.;* and April 10, of *Pheidole sp.*, *P. vinlandica longula* Emery, and *Lasius niger sitkaensis* Pergande. Figure 4 shows the increasing number of active species from March 21 to April 10, 1932.

The first to venture forth from their winter quarters were those species which occupied deep canyons. In such habitats the average temperatures were somewhat higher than on the semi-desert plains. Those species whose nests were on south- and east-facing hillsides were the next to exhibit signs of activity, this again being a temperature relationship. Next appeared those species in areas of shrubby vegetation, and then those whose nests were on the dark-colored sand plains, where the surface tended to absorb a large part of the sun's rays. Last to make their appearance were those species on





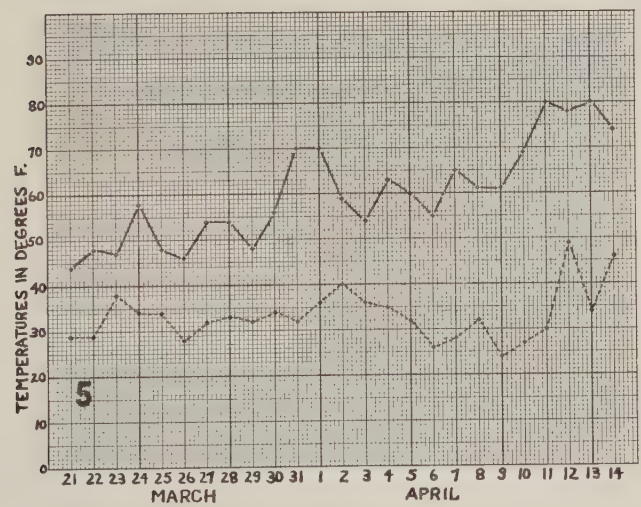


FIG. 3. Diagrammatic representation of the angle of contact of the rays of the sun. (A), rays directed against the face of a mound of *Formica obscuripes*, and (B), those directed on an area of adjoining soil surface. m, mound; r, rays of sun; l, ground level.

FIG. 4. Active species of ants at different dates.

FIG. 5. Gradual increase of daily temperature.

the lighter-colored sand plains, where much of the heat was radiated and where the soil temperatures were not so high as on the darker sands. Thus we have a gradational series of active species in a variety of habitats, from the latter part of March to the warmer days of mid-April.

The increasing early spring activity of semi-desert ants can be explained on the basis of increasing maximum and minimum daily temperatures. So closely is temperature connected with a complexity of other factors that we cannot separate it from the others, but merely place it as dominant in this particular case. Note the gradual increase of daily temperatures in Figure 5. In spite of major and minor fluctuations the increase is rather well marked, especially in the case of the maximum temperature curve. The high maximums between March 30 and April 1 ushered in eleven kinds of ants, the greatest number of additional species appearing at any one time. The most sun-loving ant of the series, *Myrmecocystus melliger semirufus*, appeared on April 1 at a maximum temperature level of 70 degrees Fahrenheit. In spite of the high maximum temperatures on days following April 10, no additional species were observed in an active condition (Figure 4).

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THE VALUE OF AN OBSERVATION HIVE OF HONEYBEES IN THE TEACHING OF HIGH SCHOOL BIOLOGY.

ALMA A. KEELER,
Columbus, Ohio.

Observation hives had their origin in antiquity when small pieces of transparent substances such as horn, isinglass, and mica were placed in the sides of the hives. Such windows offered only a very meager opportunity for studying the behavior of the bees. A hive with a glass window was invented by Mr. W. Mew of Easlington, Gloucestershire, England, about 1650. In 1730, Reaumur, the French naturalist placed a swarm between two panes of glass. The panes were too far apart and the bees built a row of comb on each pane, thus becoming hidden in the center. Bonnet, the Swiss naturalist recommended a hive with doors and having a space that only one row of comb could be built. About 1790, Huber adopted this plan, with the result that great advancement was made in the knowledge of bee life.

Commercial beekeepers have used observation hives extensively for advertising purposes. A frame of brood and honey together with sections are placed in the observation hive. This is kept in the display window for a week or until most of the people in the vicinity have seen it.

In the school laboratory, it is one of the most convenient ways of showing the complete metamorphosis of an insect. Cells may be seen that contain eggs. If these are watched, the development of a larva can be traced to the time that the cell is sealed indicating that pupation is taking place. After pupation, the adult will cut its way out of the cell. The fact that the life history is short makes it possible to trace through the life of an individual insect in a comparatively short time. There is the added value that all stages may be present at the same time. There are few other insects so well adapted to live in the confinement of the schoolroom and at the same time to carry on its normal work.

Social organization among the insects is at its peak among the bees. They are pointed out as the best illustration of

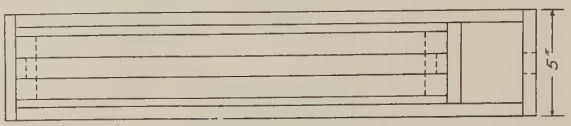


FIGURE 2.

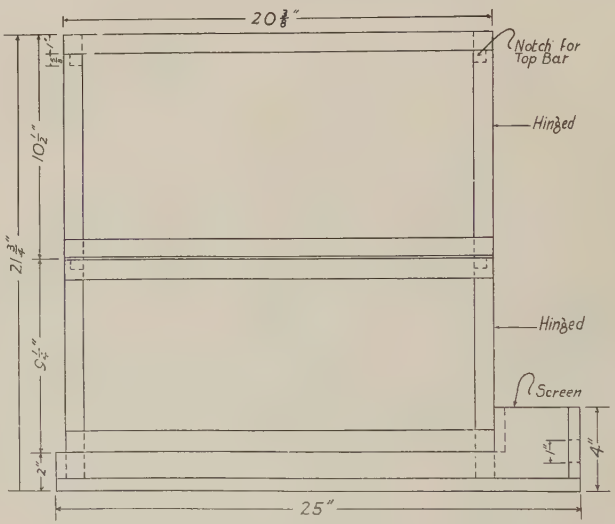


FIGURE 1.

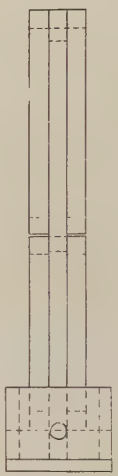


FIGURE 3.

OBSERVATION BEE HIVE.

Designed by Dr. W. E. Dunham.
Drawn by K. D. Powers.

BILL OF MATERIAL.

2 pieces ½″ by 3½″ by 24″
1 piece ½″ by 5″ by 25″
8 pieces 1″ by 1″ by 20⅜″
4 pieces 1″ by 1″ by 10½″
4 pieces 1″ by 1″ by 9¼″
2 pieces 1″ by 1″ by 21¾″
1 piece 1½″ by ½″ by 5″
1 piece 2″ by ½″ by 5″
1 piece 3½″ by ½″ by 3½″
2 pieces of window glass 18⅞″ by 9″
2 pieces of window glass 7¾″ by 9″
4 small hinges
2 small hooks
1 piece of screening 5″ by 25″
2 standard Hoffman frames

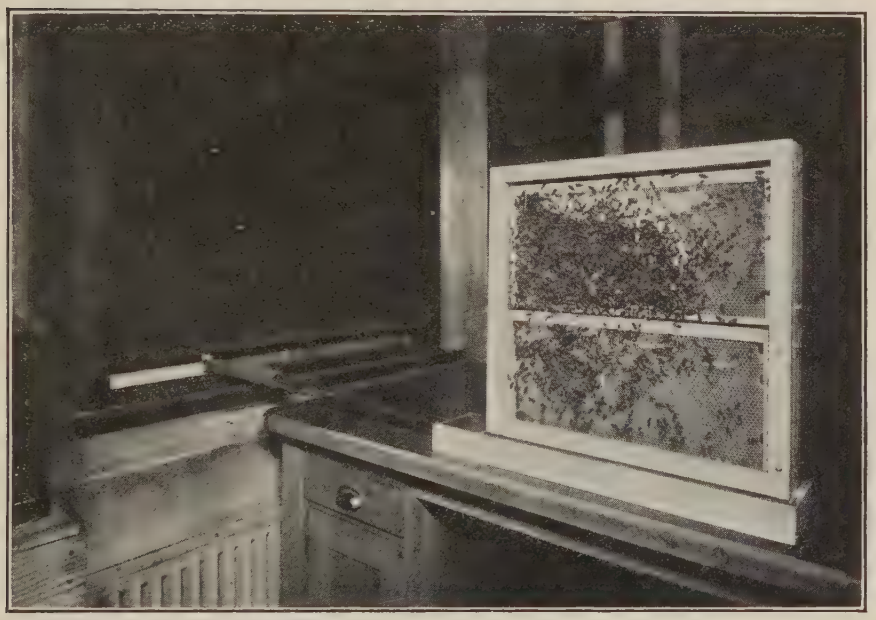
Inside measurement of glass must be exactly ⅜″ from edge of the top bar of the Hoffman frame.

Both sides may be hinged, but only one side is recommended.

Use an end lap joint on upper frames. All other joints are butt joints held by screws.

communistic life that has yet been evolved. The sacrifice of the individual for the group is seen as each insect uses itself to the utmost to promote the life of the colony. Its labors are never ended as long as there is food that it can gather.

Division of labor begins with the emergence of the adult bee from the cell. The newly emerged worker bees remain in the hive for about two weeks and can be seen doing a variety of kinds of work such as feeding the larvae, making wax,



building comb, cleaning, ventilating, and guarding the hive. As they become older, they fly out on short flights. Soon they will be making longer trips and can be seen coming in with either abdomen distended and full of nectar or the legs covered with pollen. Perhaps they will have both. They store their load in the cells and are ready for another trip in a remarkably short time. They are then called field bees and they continue this work for weeks or until they become worn and exhausted and can no longer get back with the last load.

The queen bee will be observed going about inspecting the cells and laying eggs in the empty ones. When she stops to rest, the nurse bees immediately gather about and feed her.

In winter, when egg laying has ceased, she feeds herself. Queens live several years.

A few drones may be seen but they either die naturally or are killed by the workers before winter comes.

The study of the bee incidentally makes one better acquainted with an occupation through which thousands earn their entire livelihood. There are over a million people who keep bees either for pleasure or profit. The annual value of honey in the United States is forty million dollars and the estimated value of bees as pollinating agents is eight hundred million dollars. The value of the wax produced is about six million dollars.

It is also beneficial for the student to see the cleanliness of the bee and consequently to understand the wholesomeness of a product that is supplied from nature's own laboratory, the nectaries of the flowers. It might be noted that honey is one of the most healthful of foods because of the ease of digestibility, being more readily digested than sugar and that it contains a useful mixture of minerals, possibly one of the vitamines, and at least four enzymes.

Plans for the making of an observation hive are shown in Figures 1, 2, and 3. The amount and kind of material are given. The building of the hive could doubtless be done in cooperation with the manual arts department.

The hive can be stocked in the fall or early spring depending on its intended use. If it is stocked in the fall, and the bees are to be carried over the winter, the observation hive as shown in Figure 1 should have a frame of honey placed above and a frame of emerging brood with a queen below. The honey should carry them over the winter but if it runs low they can be fed with a syrup made of one part of sugar and one part of water.

If the hive is installed in the spring, there must be sufficient food to last until the bees can accumulate enough for themselves. The lower frame may be drawn comb or comb foundation. The latter would be more interesting as the bees would have to build it out before egg laying could begin.

Bees may be obtained from a commercial bee supply house or a beekeeper in the vicinity might be glad to stock the hive. The kind of bees is not important. However the Italian bees are usually preferred as they do not bring in so much unnecessary propolis.

The hive can be located at almost any convenient place in the laboratory and a rubber tube used to connect it to the outside of the building or outside of a window. The bees will readily use this entrance. If the hive can be near a window, it may be placed on a level with the window sill so that the entrance will pass under the window sash. The space on each side is closed with boards.

The hive, if properly stocked, requires little attention other than to see that there are sufficient stores and that the temperature does not fall to freezing without the hive being covered. If the honey supply is low, sugar syrup must be given.

A certain amount of dwindling may be expected but on the whole, the bees will set up housekeeping, go to the fields when the weather permits, and carry on their ordinary work as though there were no prying eyes to see and with small loss in numbers.

The Study of Life.

This English biology written for students preparing for the School Certificate Examination is a very attractive book. In size and make-up it compares very favorably with our recent High School texts. It is built largely of a series of topics which center around the study of type forms. However, many of the newer physiological ideas are included. It is a pleasure to find a biology of this kind in which respiration and energy release are correctly treated. Throughout the book the basic ideas of cause and effect are clouded by the usual teleological statements which involve purpose and need. Thus on p. 67 one reads, "Secondly, water is the basis of all protoplasm, so the plant needs it for that reason." The numerous illustrations are excellent and are appropriate in the places where they are used.—W. M. Barrows.

Biology: An Introduction to the Study of Life, by H. Munro Fox. 332 pp., 151 figures. Cambridge, The University Press, (in U. S. A. The Macmillan Co.). 1932.

THE JOURNAL CHANGES EDITORS.

At the recent meeting of the Administrative Board of the Ohio Journal of Science, Prof. Herbert Osborn requested that he be relieved of his duties as Editor of the Ohio Journal of Science, in order that he might have more time to devote to other interests. Prof. Osborn's resignation was accepted by the Board with expressions of regret and of sincere appreciation for his services during the three years he has served as Editor of the Journal. Dr. Osborn's successor as Editor will be Dr. L. H. Snyder, who was elected unanimously by the Board to fill this position. Dr. Snyder is well qualified for this post, having served the Journal during the past year as Associate Editor. By a decision of the Board the position of Associate Editor will not be filled, at least for the time being. The entire present Editorial Staff was also re-elected for the coming year. However, the Board also put itself on record as favoring some plan limiting the period of service of the members of the Editorial Staff, so that the term of office for a certain proportion of the membership will terminate each year. This will allow the Board to make systematic changes in the Editorial Staff from time to time, thus bringing to the service of the Journal new interests and new points of view. While this plan has not yet been put into operation, it probably will be initiated at the next annual election of officers for the Journal.

B. S. Meyer, *Secretary,*
Administrative Board of the Ohio Journal of Science.

NOTE.

With the present volume the writer terminates his service in the editorial management of the Journal and is pleased to know that it will be in the hands of Dr. Snyder, whose services as associate editor have been of great assistance during the past year. The *Ohio Journal of Science* and its predecessor, the *Ohio Naturalist*, have been objects of continuous interest from the inception thirty-two years ago and the three years past during which I have served as editor have brought many delightful associations. Naturally, the future of the Journal will be watched with interest and its successes noted with sincere pleasure.

Herbert Osborn.

INDEX TO VOLUME XXXII.

Abstracts, 320. (For Titles see List of Papers in Proceedings, pp. 301–304.)
Anderson, Bertil Gottfrid, 322.
Baird, Robert L., 321, 323.
Berry, Willard, 328.
Bevan, Arthur, 329.
Blake, F. C. and Ford, E. W., 342.
Bowland, D. W., 344.
Boyd, M. J., 334.
Braun, E. Lucy, 326.
Brown, W. E., 334.
Burhans, N. C., 355.
Corney, G. W., 328, 351.
Edwards, J. S., 343.
Elliott, Rush, 337.
Federighi, Henry, 320.
Foshay, Lee, 335.
Furcron, A. S., 330.
Frost, Reuel B., 353.
Garland, John H., 354.
Graham, Wm. A. P., 330.
Graves, Grant O., 341.
Grubbs, Robert C., and Hitchcock, E. A., 336.
Haines, J. F., 344.
Haun, R. R., 345.
Hayhurst, Emery R., 337.
Heyroth, Frances F., and Loofbourow, J. R., 332.
Hicks, Lawrence E., 326.
Howe, Carl E., 343.
Hubbard, Geo. D., 330, 331, 354.
Irish, Don D., 333.
Jarvis, C. W., 344.
Johnson, J. J., and Jarvis, C. W., 344.
Kehoe, Robert A., 334.
Kuechle, Theo. F., 347.
Lamb, G. F., 331.
Lord, James O., and Blake, F. C., 342.
Lord, Richard C., 330.
Loring, Ralph A., 345.
Lumer, Hyman, 324.
Matson, J. R., and Hitchcock, F. A., 335.
McCormick, Robert N., 322.
McConnell, W. R., 349.
Nice, L. B., and Katz, H. L., 341.
Nice, Margaret Morse, 321.
Oltman, R. E., 327.
Roth, Herman, 347.
Rothmund, Paul, 338.
Rowles, E., and Patrick, J. R., 332.
Rowles, E., and Shurrager, P. S., 340.
Rugby, George, 325.
Sawyer, Carl W., 339.
Schmidt, L. H., 336.
Scranton, Robert, and Lamb, G. F., 331.
Sears, W. C., 345.
Selbert, Norma, 338.
Shawnan, E. N., 343.
Smith, Guy-Harold, 352.
Spencer, Warren P., 325.
Stockdale, Paris B., 351.
Stout, Wilber, 350.
Stupka, Arthur, 321, 323.
Swinnerton, A. C., 331.
Tashiro, Shiro, 333.
Thomas, E. S., 320.
Thomas, Thurlo, 324.
Transeau, E. N., 349.
Twitchell, George B., 328.
Vack, Christine M., 333.
Varvel, Carl Dudley, 353.
Ver Steeg, Karl, 354.
Waller, A. E., 350.
Williams, S. R., 322.
Wright, Alfred J., 352.
Addition to Known List of Ohio Mammals, 402.
Alcyonidium parasiticum, 444.
polyoum, 443.
verilli, 443.
Alimentary Canals of Bean Beetle, 249.
Amathia alternata, 444.
Ancient Drainage in Ohio, 481.
Anguinella palmata, 444.
Ant, Formica subpolita Mayr, in the Western United States, Nests of, 245.
Ants, Observations on Semi-Desert, 533.
Ant, Pogonomyrmex occidentalis Cr., Associated with Plant Communities, 10.
Ant, Pogonomyrmex occidentalis Cr., Relation to its Habitat, 133.
Ant, Pogonomyrmex occidentalis Cress., Rebuilding of Mounds, 245.
Ant, Rebuilding of the Mounds of the, 245.
Arisaema triphyllum, Sex in, 147.

Baldwin, Kendeigh, and Franks, article by, 403.
Barrows, W. M., and Shensa, article by, 507.
Basal Oneota Dolomite, 527.
Berry, Willard, articles by, 194, 385.
Blowfly, Fertility in, 389.
Blue Hole of Castalia, 425.
Bole, B. P., Jr., article by, 402.

Book Notices, 114, 146, 151, 161, 193, 196, 231, 236, 244, 262, 355, 360, 378, 384, 388, 402, 435, 440, 471, 472, 480, 486, 512, 532.
Bowerbankia gracilis, 444.
Brand, L. S., articles by, 55, 95.
Bryozoa from Chesapeake Bay, 441.
Bugula turrita, 442.
gracilis var. uncinata, 443.
Burgess, Emory D., 249.

Calcified Wood, 55.
Callixylon Newberryi, 385.
Camp, W. H., articles by, 147, 197.
Camp, W. H., and Chapman, article by, 197.
Cephalopod Genera, 163.
Chapman, A. G., and Camp, article by, 197.
Coal and Mica Deposits, 95.
Coddington, E. F., article by, 366.
Cole, Arthur C., Jr., articles by, 10, 133, 245, 247, 533.
Columbus, Where is, 366.
Couch, Glenn C., and Sears, article by, 63.
Cowan, Frank A., article by, 389.
Crisia eburnea, 442.
Ctenostomata, 443.
Cyclostomata, 442.
Cyrtendoceras estoniense, 168.
hircus, 167.
remelei, 165.
schmidti, 169.

Dehus, Dolores, and Snyder, 232.
DeLong, Dwight M., article by, 393.
Doan, Charles A., Miller, and Wilson, article by, 1.
Dominance of Man, 232.

Ectoprocta, 442.
Editor's Note, 424.
Electra pilosa, 443.
monostachys, 443.
Empoasca, Nine New Species of, 393.
bidens, 397.
bitubera, 395.
calcara, 398.
calcea, 395.
infusca, 398.
medora, 397.
obrudens, 393.
reflexa, 396.
rubrafacia, 394.
Enders, Robert K., article by, 21.
Endoprocta, 442.
Epilachna corrupta, 249.
Eucrangonyx Mucronatus Forbes, 356.
Evolution, Orthogenetic, 367.

Flower Production in the Lemnaceae, 115.
Foerste, Aug. F., article by, 163.
Food Habits of Utah Lizards, 467.
Formica subpolita, 247.
Fossil Trigonocarpus, 194.

Galvanotropism of the Earthworm, 507.
Genus Temnogametum, 487.
Geographic Conditions, Influences, Controls, 39.
Graham, Wm. A. P., article by, 527.

Hawks and Owls in Ohio, Protection of, 403.
Hemiseptella denticulata, 443.
Hemophilia, 152.
Hippothoa hyalina, 443.
Hubbard, George D., articles by, 39, 473.
Hubbs, Carl L., and Trautman, article by, 31.
Human Inheritance, Studies in, 152, 436.

Keeler, Alma A., article by, 539.
Kelsheimer, E. G., article by, 85.
Knowlton and Janes, article by, 467.

Lamb, G. F., and Scranton, article by, 481.
Lamborn, R. E., article by, 449.
Leafhopper Response to Colored Lights, 85.
Leafhoppers, Supplemental List of Ohio, 513.
Lemnaceae, Flower Production in, 115.
Light Reactions on Cladocera, 218, 324.
Liriodendron tulipifera L., 104.
Lumer, Hyman, article by, 218.

Meyer, Bernard S., article by, 104.
Microfossils in an Arkansas Peat, 63.
Microporella ciliata, 443.
Miller, David F., Doan, and Wilson, article by, 1.
Muskrat, Food of in Summer, 21.

Nationalistic Elements in Ohio Farming, 518.
Nelson Ledge State Park, 177.
Newark Drainage System, 449.
Nitscheina membranacea, 443.
Notices and Comment, 68.

Observation Hive of Honeybees, 539.
Oelandoceras byrumense, 171.
haelluddenense, 170.
kristdalaense, 171.
Ohio Leafhoppers, 513.
Ohio Vascular Plants for 1931, 158.
Oklahoma Rotifers, 492.
Orthogenetic Evolution, 367.
Osborn, Herbert, article by, 513.
Osburn, Raymond C., article by, 441.

Osteomyelitis, Treatment of with Fly Larvae, 1.

Pelargonium, Starch Synthesis in the Variegated Leaves of, 197.
Physics and Human Experience, 305.
pH Tolerance of the Lemnaceae, 237.
Poecilichthys osburni, 31.
Pogonomyrmex occidentalis, 10, 133, 245.
Polydactylism, 232.
Precambrian in Ohio, 473.
Presidential Address, 305.
Protection of Hawks and Owls in Ohio, 403.
Pseudacris Brachyphona, 379.

Report of the Ohio Academy of Science, Forty-second, 266.

Schaffner, John H., articles by, 158, 367.
Schizopodrella unicornis, 443.
Scranton, Robert, and Lamb, 481.
Sears, Paul B., and Couch, article by, 63.
Shensa, Lewis S., and Barrows, article by, 507.
Smith, Alpheus W., article by, 305.
Snyder, Laurence H., articles by, 152, 232, 436.
Snyder, Laurence H., and Dehus, 232.
Stalactites and Stalagmites, 69.
Starch Synthesis, 197.
Studies in Human Inheritance, IX, 436.

Taft, Clarence E., article by, 492.
Taste Deficiency in Man, 436.
Temnogametum, 487.
Transeau, Edgar Nelson, article by, 487.
Transpiration in the Poplar, 104.
Trautman, Milton B., and Hubbs, article by, 31.
Trigonocarpus, 194.
Tritecella elongata, 445.

Varvel, Carl Dudley, article by, 518.
Ver Steeg, Karl, article by, 69, 177, 425.
Ver Steeg and Yunck, article by, 425.
Victorella pavida, 445.

Walker, Charles F., article by, 379.
Wilson, E. Harland, Miller and Doan, article by, 1.